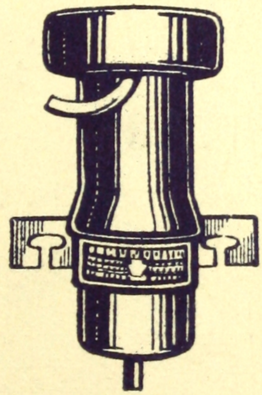
CRYSTAL VALVE

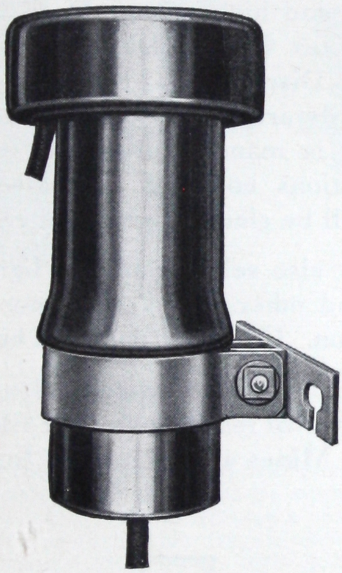
LIGHTNING ARRESTERS



and other protective Apparatus

ELECTRIC SERVICE SUPPLIES Co.

KEYSTONE CRYSTAL VALVE LIGHTNING ARRESTERS



Typical Keystone "Crystal Valve" Arrester

ELECTRIC SERVICE SUPPLIES CO.

Manufacturer of

Railway, Power and Industrial Electrical Equipment

PHILADELPHIA 17th and Cambria Sts. — **NEW YORK** 50 Church St. — **CHICAGO** 111 No. Canal St.

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Lyman Tube & Supply Co., Ltd., Montreal, Toronto, Vancouver

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This Bulletin covers the complete line of lightning arresters and lightning protective apparatus manufactured by this Company. These lines include Keystone Crystal Valve Lightning Arresters for high and low voltage A. C. service and for low voltage D. C. service; Garton-Daniels Lightning Arresters for low voltage A. C. and D. C. service and for standard and high voltage D. C. railway service; Keystone and Protex Radio Lightning Arresters; Ground Fittings; Keystone Disconnecting Switches and Choke Coils. Standard items only are listed herein; much lightning protective apparatus is manufactured for special conditions and recommendations covering equipment for any such special service will be gladly made upon request.

This Company also sells Franklin High Voltage Porcelain Insulators and other high voltage porcelain insulators of every description. Complete data will be sent on request.

Electric Service Supplies Company also sells broad lines of equipment of its own manufacture for Electric and Steam Railroads, Mines and Industrial Institutions.

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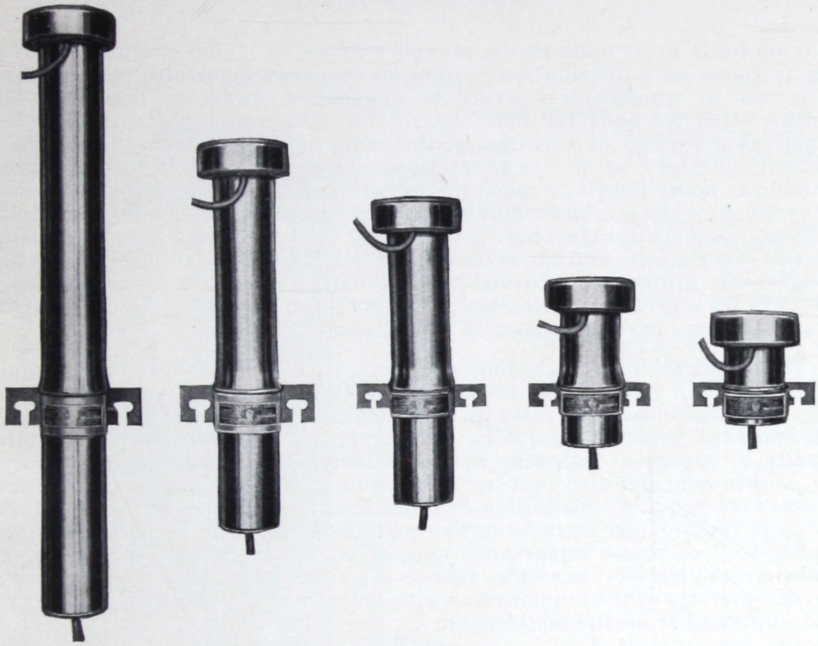

Crystal Valve Lightning Arresters for 350-15,000 Volt A. C. Service
(See p. 30 for 25,000 V. Arrester)

As a result of elaborately planned and executed experimental work that has been conducted for more than ten years by several of the largest Central Station Companies in the country, it has become a recognized standard practice on distribution circuits to protect every transformer with lightning arresters installed directly on the transformer pole. This is in marked contrast to the older practice of installing arresters at regular intervals of perhaps 2 or 4 to the mile, or even of installing them at more frequent intervals, but without particular regard to their placement with respect to distribution transformers.

This practice of protecting every transformer with arresters installed in very close proximity thereto may be considered as affording the excellent protection observed for two important reasons:—

a. Lightning disturbances in primary distribution circuits are largely of electrostatic origin and are practically instantaneously produced over a more or less extended portion of the circuit; such disturbances frequently have very steep wave fronts, the voltage building up to extremely high values during the time of a lightning flash, such time intervals ranging from a fraction of a microsecond to perhaps 5 or 10 microseconds. With such disturbances it is obvious that if the transformer is to receive adequate protection the lightning arrester must be installed right at the transformer itself and not perhaps a pole length or more distant; the impedance offered by one hundred or even twenty-five feet of line conductor to a traveling wave of steep front is tremendous and in many instances would be ample to practically nullify the protection that would be afforded apparatus by arresters installed at a distance therefrom.

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This leads us at once to the second reason: *b.* That the density of lightning arresters on a distribution system plays a very important part in affording protection to transformers or other apparatus connected thereto. This is obvious when we consider that electrostatic charges may be set free over a considerable portion of a system at the same instant, and, this being the case, lightning arresters, or electrical safety valves as they may be called, should be available at many points to carry the resulting disturbances to ground; in other words, by providing a large number of parallel paths from line to ground, the protection is very measurably increased. This has been amply demonstrated through service tests and for certain localities it has been found that the degree of lightning protection afforded transformers connected to the distribution system bears a given mathematical relation to the density of lightning arresters installed on any particular portion of the system.

The application of lightning arresters to distribution circuits should be considered both from the standpoint of individual transformer protection and from the standpoint of density of lightning arrester installations. It is therefore standard practice generally to protect all transformers irrespective of capacity by means of lightning arresters installed directly on the transformer pole, and to consider also that for isolated or sparsely spaced transformers line arresters are required in addition to those installed directly at the transformers. For large transformer installations or installations of any size where continuity of service is of prime importance special protection should be provided, this special protection, for example, taking the form of arresters and choke coils installed directly at the transformer with added line arresters installed at points not too distant from the installation.

From the foregoing it will be apparent that lightning arresters designed for the protection of apparatus on distribution circuits should have certain inherent characteristics; these may be summarized as follows:—

a. They should give efficient and reliable lightning protection; by this is meant that their initial breakdown or relief voltage should be low and commensurate with the breakdown voltage of the insulation which they are used to protect; that they should have a high discharge rate or a discharge path of low impedance in order that surge voltage on the system may be held to a safe value; and they should be constructed along such lines that they do not represent a hazard to the distribution system on which they are installed through arrester grounds or short-circuits from their failure to properly operate over a long period of years.

b. They should be easy and cheap to install and inspect.

c. They should be small enough to be installed directly on the transformer pole without crowding.

d. They should be relatively inexpensive, not only so that their use in connection with every transformer, irrespective of capacity, may be justified, but as well that for certain conditions line installations may be economically justified as well.

e. They should be durable and have long life; in other words, they should be constructed of elements which suffer little deterioration with time and should operate on principles which permit initial operating characteristics to be rigidly maintained through long operating life.

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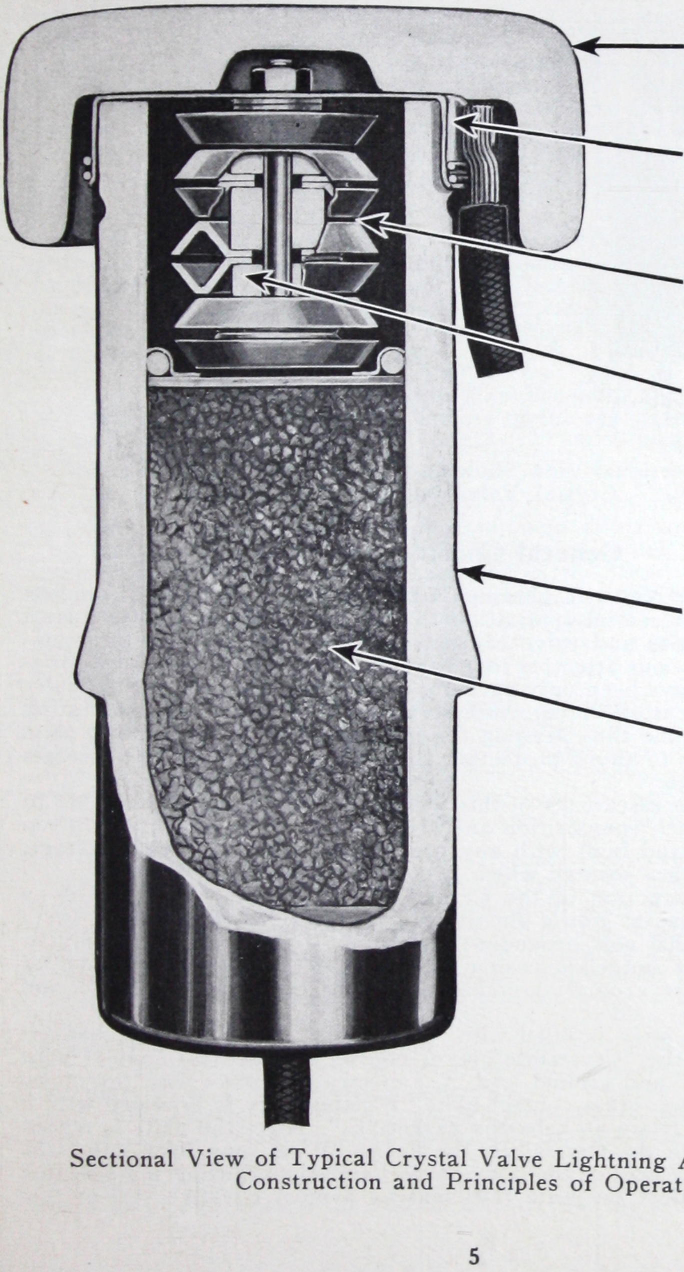

GLAZED WET PROCESS PORCELAIN CAP protecting arrester and line lead.

COPPER HAT used as a further protection to internal arrester parts from possible moisture or rain due to cracked or broken cap.

HEAVY HIGH SPEED BRASS DISCHARGE PLATES having arcing surfaces capable of handling many lightning discharges with little deterioration.

AIR GAP SPACERS OF ISOLANTITE, accurately ground to exact dimensions, assembled with the discharge plates on insulating tie rod and securely positioned and held by nuts threaded onto same. This gives gap adjustment of great accuracy and assures an extremely sensitive and permanently efficient unit.

GLAZED WET PROCESS PORCELAIN BODY housing arrester elements—a permanent, enduring case.

"CRYSTALLITE"—the active and basic element of the Crystal Valve Arrester. This material gives this arrester its highly efficient and true valve action; its low internal impedance and extremely high discharge rate. It does not measurably deteriorate in service. It is on account of these remarkable properties that the Crystal Valve Arrester is initially an arrester of great reliability, durability and of extremely high efficiency, maintaining this high efficiency practically indefinitely.

Sectional View of Typical Crystal Valve Lightning Arrester Showing Construction and Principles of Operation

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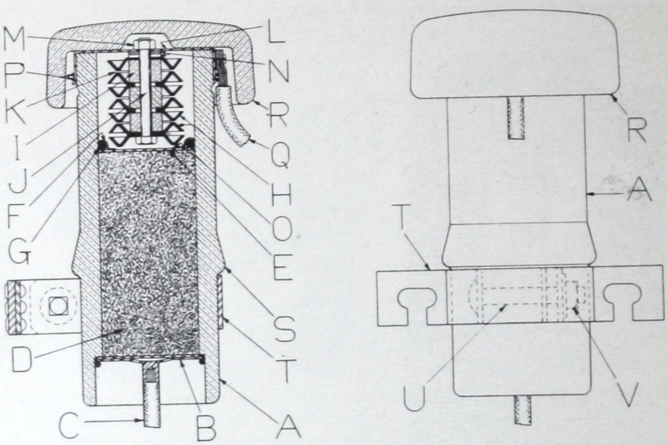

Figure 2. Sectional View Showing Construction of Typical Crystal Valve Arrester

General Construction

Keystone Crystal Valve Lightning Arresters represent an outstanding development in the successful application to lightning protective apparatus of the rectifying properties and valve characteristics of certain refractory conductive crystals. Previous attempts that have been made to utilize these properties commercially have been only partially successful, owing to the difficulty in building the valve cut-off voltage sufficiently high for present-day operating voltages and at the same time keeping the impedance of the crystalline mass to a value low enough to afford protection against lightning discharge currents of relatively high value.

Through intensive researches in this field this Company has been able to develop crystals of such composition and structure that not only can a given arrester be designed and built with any predetermined valve cut-off voltage, but as well an impedance secured which is of an extremely low value.

The general construction of the Crystal Valve Lightning Arrester is as shown in Fig. 2 herewith, which illustrates a sectional view of a type CV-3 unit for service on 2300 volt grounded Y circuits. It consists essentially of the main wet process porcelain casing or body "A" into the lower end of which is cemented the ground assembly consisting of brass plates "B" and ground lead "C."

A portion of the body is filled with "Crystallite" "D" tightly packed in; the lower surface of the "Crystallite" is, of course, in electrical contact with the ground plates "B" and ground lead "C"; electrical contact with the upper surface is made through brass contact plate "E"; this plate is provided with a copper flange "F" to retain an asbestos gasket "G." After the plate is forced into tight contact with the Crystallite, the flange "F" is spun over into tight contact with the inside wall of the body at the same time causing the asbestos gasket to expand against the wall, thus making a most effective seal at this point.

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Spark gap electrodes "H" separated by Isolantite spacers "I" are assembled on the insulating tie rod "J" to form spark gaps "K," the number and length of the gaps being proportioned to the operating voltage of the arrester. A copper cap or hat "L" fits over the entire top of the body and serves not only to entirely seal the upper end of the body (preventing ingress of moisture should the porcelain cap become accidentally broken in service) but as well supports the spark gap assembly, the insulating tie rod "J" projecting therethrough and by means of nut "M" the discharge electrodes are tightly drawn into fixed position and the entire spark gap assembly rigidly and securely held to the copper hat.

Brass washers "N" of varying thicknesses are interposed between the lower surface of cap "L" and upper discharge electrode "H" to compensate for slight tolerances in manufacture or assembly, as, for instance, in the overall length of porcelain body "A" as well as to conveniently provide an additional spark gap "O" between the lower spark gap electrode and the upper surface of contact plate "E."

Cap "L" is securely held to the porcelain body by means of tension band "P" which encircles the cupped portion of the cap as shown; line lead "Q" is securely clamped and soldered to cap "L" in a terminal structure formed integrally with the cap.

Wet process porcelain cap "R" fits over the assembled arrester and is held in position by means of a sealing compound filling up the space between it and the exterior of the body; this sealing compound is securely locked to these two members through the sanding of the inner surface of the cap and the seal retaining groove on the body, seen just below the copper hat. This porcelain cap in conjunction with the copper hat "L" serves to effectively seal the arrester and prevents the ingress of water or moisture to the internal assembly.

The body is provided with the bead "S" which serves as a retainer for the arrester in the clamping band "T," several types of which are available as listed hereinafter; these are made of hot galvanized steel and after slipping over the body are securely clamped thereto by means of the bolt "U" and nut "V"; holes are provided in the clamping band for attaching to the cross arm or other suitable support, so providing a strong, rigid support for the arrester.

It will be noted that much care has been given to every detail entering into the construction of the Crystal Valve Arrester; the methods adopted for sealing in the Crystallite provide absolutely tight seals for crystals of the largest and smallest sizes employed; air gaps are formed between our standard high speed discharge electrodes, separated by accurately ground Isolantite spacers and are retained in accurate position and adjustment by being assembled on the insulating tie rod and clamped in position by means of nuts threaded onto same; due to this method of assembly and as well to the fact that no springs whatever are used for positioning any of these elements, the air gaps can be and are accurately checked before assembling into the arrester, thus assuring the user of uniform arrester characteristics. Ingress of moisture to the arrester elements is efficiently prevented through the use of the highest grade wet process porcelain for both bodies and caps as well as by the solid copper hat covering the upper end of the porcelain body; this protection is so effective that the arrester will suffer no injury should, for example, the porcelain cap in some accidental manner be broken off. It will be noted also that since the

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spark gap assembly is suspended from the copper hat and since this assembly is separated by an accurately measured gap from the upper Crystallite contact plate, the porcelain body is placed under no strain in maintaining this accurate positioning of these elements, but performs only the two essential functions of protecting the internal assembly from the elements, and of offering a means of attaching the arrester to a suitable support.

General Theory of the Crystal Valve Arrester

The discussion of the theory underlying the Crystal Valve lightning arrester quite properly may be taken up under three main headings, these representing three of the important fundamental characteristics of lightning protective apparatus. These are:—

a. Arc-over or relief voltage.

b. Dynamic or circuit power characteristics.

c. Internal impedance.

These characteristics in relation to the theory of the Crystal Valve arrester will now be discussed.

Arc-Over or Relief Voltage

The arc-over voltage of a lightning arrester must be based on a compromise between two main factors:—

a. If it is set too close to normal line voltage, the arrester becomes too sensitive to switching surges and other harmless voltage disturbances and gives no appreciable gain in the life of the apparatus which it protects.

b. If it is set too high it imposes an unnecessary strain on the insulation of apparatus which it is designed to protect, and even though this setting is well within the limit of where the insulation would be punctured by these transients, yet a recurrence of these voltage strains, even with a low impedance arrester, cannot help but gradually weaken the insulation of the apparatus and so hasten its time of ultimate failure.

Basing our practice on years of experience in the building of lightning protective apparatus, on the inherent characteristics of the Crystal Valve Arrester, and on the conditions which the arrester must meet in actual service, we have adjusted the relief voltage of these arresters to such values that a very well-balanced design obtains for all of the various factors entering into the problem.

The arc-over or relief voltage of the arrester is controlled largelv by the length and number of the spark gaps "K" (Fig. 2); the length of the Crystallite path and the size of the individual crystals affect the relief voltage but slightly. Hence the arc-over or relief voltage of the arrester is subject to exact control and may be given any desired value through suitably proportioning the length and number of the spark gaps "K."

In general, the relief voltages of the various types of Crystal Valve

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Arresters is somewhat below the relief voltage of competing arresters offered for similar service; this highly efficient adjustment is made possible only because of the inherent principles underlying the construction and operation of the device and is one of the factors that is directly responsible for the highly efficient protection given by these arresters.

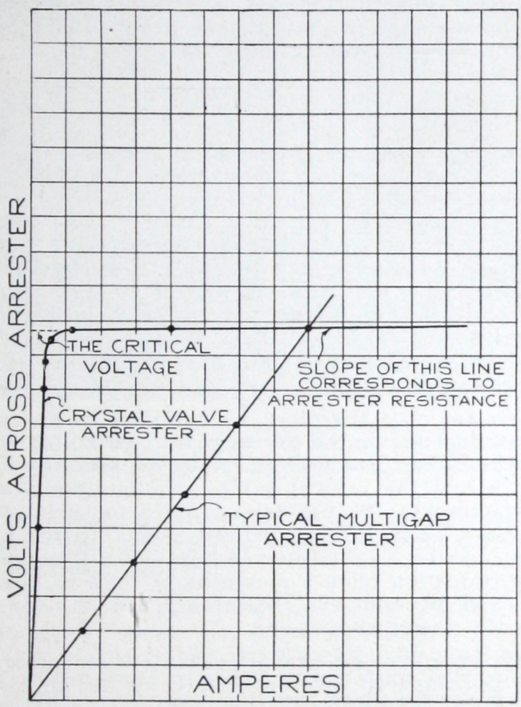

Figure 3. Valve Characteristics of Crystal Valve Arrester and Typical Multi-Gap Arrester

Dynamic or Circuit Power Characteristics

One of the inherent properties of the Crystallite used in the Crystal Valve Arrester is its "valve" characteristics—its ability to permit only an extremely small current to flow through it at voltages under a certain critical value; for voltages above this critical value it becomes a good conductor permitting relatively heavy current to flow. If, therefore, a material having this characteristic is used in a lightning arrester and it is so employed that its critical voltage is higher than the normal voltage of the circuit on which it is used, while the arrester will offer a path of very low resistance to high voltage surge currents practically no dynamic or circuit power at normal circuit voltage will flow through the arrester following a lightning discharge, and

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hence no provision need be made in the arrester for interrupting such current flows. Such an arrester is known as a "valve type arrester."

Primarily, a valve type arrester functions somewhat similarly in electrical circuits as a safety valve functions, for instance, on a boiler. A safety valve may normally be set for, say, 100 pounds pressure, which may be called the "critical pressure"; and be installed on a boiler whose normal or working pressure is 90 pounds; suppose the steam pressure suddenly rises to 150 pounds; the valve opens and allows this excess steam to blow off; the pressure immediately begins to decrease, and when it has fallen to, say, 99 pounds, the valve closes. We have in this assumed case relieved the boiler and steam line of *"excess pressure"* above a certain *"critical value,"* but have not permitted any steam at *"normal pressure"* to discharge.

We may quite similarly assume an electrical circuit, the normal voltage to ground of which is 2500; also assume that connected to this circuit is a valve type lightning arrester, having a relief voltage of 5000, and that 5000 volts also represents its critical valve voltage. Assume now that there appears on the circuit an induced voltage of 100,000; the arrester immediately opens up and allows this excess voltage to flow to ground; immediately after the arrester begins to discharge, the abnormal circuit voltage begins to decrease, and when it has fallen to 5000 volts, the "critical valve voltage" of the arrester, the arrester automatically closes. We have thus relieved the line of *"excess voltage"* above a certain *"critical value,"* but have not permitted any current at *"normal voltage"* to flow to ground.

A valve type arrester may, therefore, be described as an arrester in which the discharge current depends on the excess of applied voltage over the critical valve voltage of the arrester. In a perfect valve type arrester no current would flow with voltages below the critical value. No modern arrester possesses a perfect valve characteristic, the nearest approach to such a condition being attained in the Crystal Valve arrester where, owing to the purely electrical valve characteristics of the Crystallite, and its low impedance beyond the critical voltage, the transition from a condition of high to low impedance for voltages rising to and beyond the critical voltage is not only extremely marked, but practically instantaneous.

Fig. 3 herewith shows valve characteristic curves of a Crystal Valve Lightning Arrester as compared with an arrester of the multigap type. Note that, whereas in the multigap arrester the flow of current is approximately proportional to the applied voltage (after arc-over of the arrester has occurred), in the Crystal Valve Arrester practically no current flows until the voltage has risen to the critical value at which point the internal arrester resistance decreases tremendously and allows very heavy flows of surge current at relatively slight voltage increases.

The fact that the Crystal Valve Arrester is of the true valve type gives it the following important advantages:—

a. Their internal impedance may be made extremely low, thus providing more efficient protection to apparatus.

b. Their initial breakdown voltage may be made lower than is feasible with arresters of the multigap type, this also resulting in increased protection to apparatus.

c. Since the only energy that is absorbed by a valve type arrester is that of the surge, such arresters will function well under rapidly recurrent and

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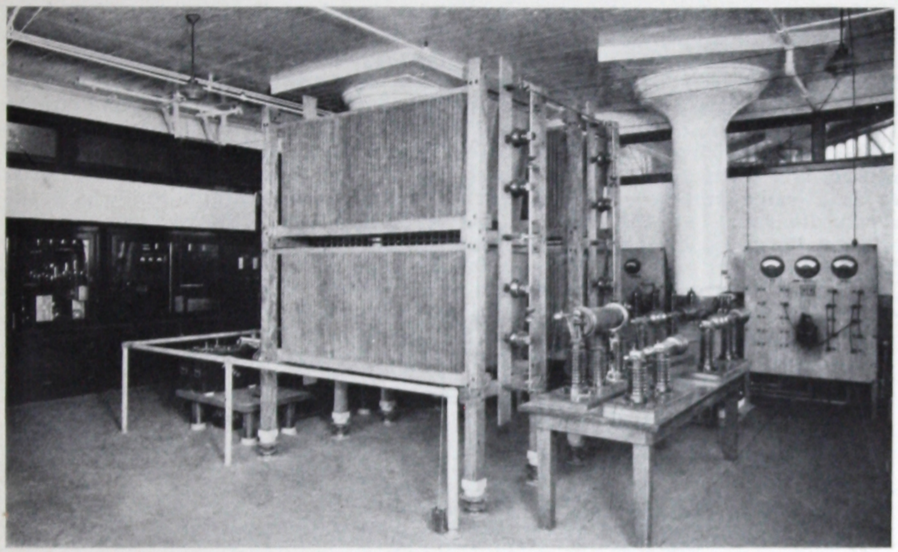

Figure 4. View of Lightning Generator Employed for Lightning Arrester Development and Testing

long-continued discharges without fear of self-destruction from the normal line current, and as well with the least possibility of causing possible service disturbances through such failure.

d. Valve type arresters possessing extremely efficient characteristics may be constructed in much smaller size as compared with less efficient arresters of the multigap type. This results in an arrester of small size that can generally be installed on the most crowded transformer pole, and as well through its comparatively cheap cost may be freely employed for protecting all classes of electrical apparatus.

Impedance Characteristics

One of the most interesting subjects in connection with the Crystal Valve Arrester is the study of the factors influencing its extremely low internal impedance, and the manner in which this is co-ordinated with the relief and critical valve voltages to effect the balanced structure responsible for the highly efficient protection given by this arrester.

The active element of the Crystal Valve Arrester—Crystallite—is a refractory conductive crystal, the conductivity of which is a function of the applied voltage, increasing as the applied voltage is increased; this property is inherent to the crystal itself, and exists both in the free crystal as well as in a discrete mass of closely packed free crystals, such as is found in the Crystal Valve Arrester.

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In the packed crystals there exists also a valve effect, such as has been already described, which valve effect for a given crystal mass is also a function of applied voltage and, for simplicity, may be considered as a resistance, the conductivity of which increases as the applied voltage increases. The critical valve voltage, or the voltage at which the ordinarily low conductivity of the mass changes to conductivity of a very high order, maintaining this high conductivity for impressed voltages equal to or higher than the critical voltage, is a fixed value for any given Crystal Valve Arrester, and since it is set at a value somewhat higher than the maximum voltage for which the arrester is rated, no appreciable amount of dynamic or power current will follow a lightning discharge to ground. (See Fig. 3.) The relief voltage of the arrester is set at a value quite near the critical valve voltage, hence at the time the arrester operates the applied surge voltage exceeds the critical valve voltage, reduces the initially high valve resistance to a very low value and

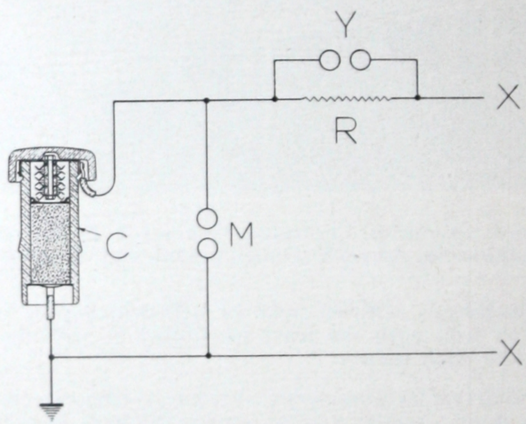

Figure 5. Circuit Employed for Determining Lightning Arrester Impedance Characteristics

there consequently remains in the discharge path for the surge current only the impedance of the crystal mass. It is important at this point to state that the critical valve voltage of the crystal valve arrester may be easily controlled and is primarily a function of the length of the crystal path and of the size of the crystals themselves; the critical voltage increases as the length of the crystal path increases, and as the size of the crystals decreases.

To return now to the impedance of the arrester to surge current. These characteristics are best shown by means of tests made on the lightning generator. Fig. 4 shows one view of our lightning generator with which these and other high voltage high current lightning arrester tests are made. This generator at full output produces a transient of approximately 16,000 amperes at 100,000 volts—over one and a half million KVA—and with it we are able to subject arresters in the laboratory to tests far more severe than occur under service conditions except in very infrequent instances.

Fig. 5 shows the schematic set-up of the lightning generator for the study

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of arrester impedances; in this figure "X-X" represents the terminals of the lightning generator, "R" a known resistance in the test circuit, and "Y" an adjustable gap across the terminals of the resistance, by which the voltage drop across the resistance may be measured and from this and the known resistance "R" the value of surge current calculated. "C" represents the ar-

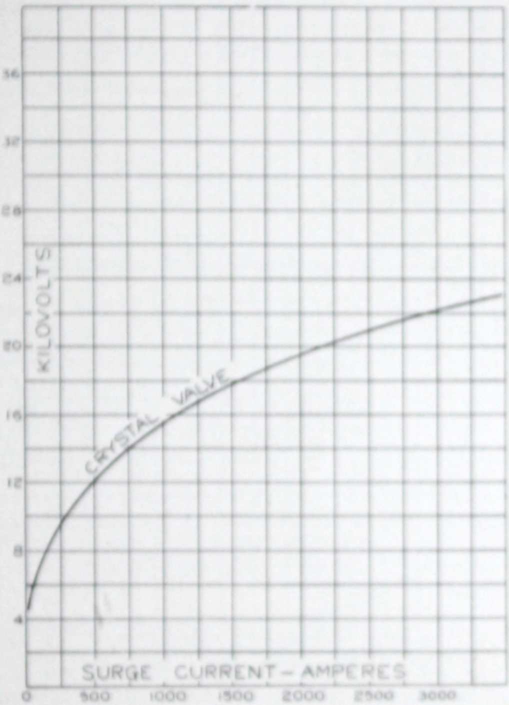

Figure 6. Volt-Ampere Characteristic Curve of Standard 3000-Volt Distribution Type Crystal Valve Arrester

rester under test and "M" an adjustable gap shunted across the arrester terminals to measure the voltage drop across the arrester due to a flow of surge current therethrough. Having now means to determine the flow of surge current through the arrester, and means to measure the voltage built up across the arrester due to the flow of this surge current therethrough, from these values we can calculate the impedance of the arrester.

Fig. 6 shows the volt-ampere characteristic curve of a 3000 volt distribution type Crystal Valve Arrester as made on the lightning generator and with the circuit set-up shown; this shows very clearly the extraordinary capacity of this arrester to discharge heavy surge currents with very low potentials built up across same and consequently with the utmost protection afforded the apparatus protected by the arrester. This characteristic curve is the one

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most generally used in determining through laboratory tests the protective value of lightning arresters under actual service conditions.

The internal impedance characteristics of the arrester may now be shown as a function either of surge current through the arrester or of surge potential

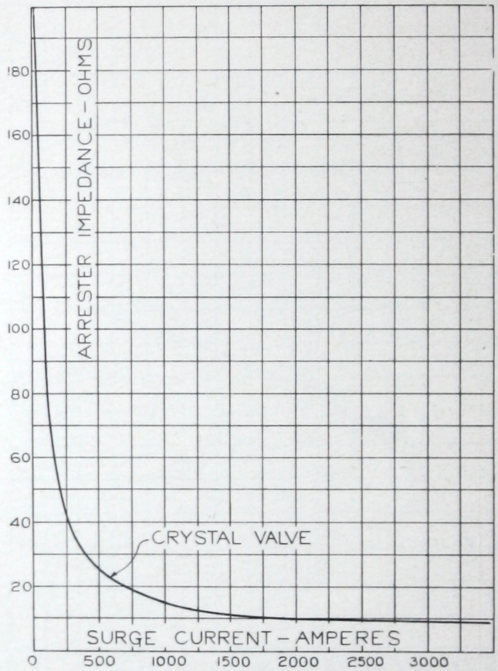

Figure 7. Impedance—Current Characteristic Curve of Standard 3000-Volt Distribution Type Crystal Valve Arrester

impressed across the arrester, both curves being derived from the volt-ampere characteristic curve just shown; such an impedance-current curve is shown in Fig. 7, from which may be observed the extremely large decrease in impedance as the arrester is called upon to discharge increasingly heavier surge current flows caused by increasingly higher voltages impressed on the arrester. As was shown to be the case with respect to the breakdown voltage and the critical valve voltage, the internal impedance of the Crystal Valve Arrester for any given set of conditions may be accurately controlled; this impedance control is effected through definitely known relationships existing between the sectional area of the crystal mass, its length and the physical dimensions of the crystals themselves; by properly co-ordinating these factors a lightning arrester may be constructed with minimum permissible impedance for any given set of variables.

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It has now been shown that—

a. The arc-over or relief voltage of the Crystal Valve Arrester may be controlled by the series air gaps.

b. The critical valve voltage may be controlled through suitably choosing the size of the crystals employed and the length of the crystal path.

c. The impedance of the arrester may be controlled by suitably varying the relation between the length of the crystal path, its sectional area and the physical dimensions of the crystals themselves.

It is thus seen that by co-ordinating and balancing these factors it is possible to secure an arrester which possesses any desired value of relief voltage, any desired critical valve voltage and an internal impedance of minimum value. It is the discovery and the practical application of these principles in the Crystal Valve Arrester that makes this arrester stand apart as such an outstanding and successful development in the lightning arrester field.

Cathode Ray Oscillograph Tests

Closely related to the foregoing principles of lightning arrester design and functioning is the matter of speed of operation. This characteristic is directly associated with the arc-over or relief voltage and with the internal impedance of the arrester. In other words, low relief voltage to be effective necessitates that the spark lag of the gaps, and of the characteristic element associated therewith in the arrester, be small, so that the arrester as a whole will begin to operate as soon as possible after the rising transient lightning or surge voltage is impressed upon it; after which the internal impedance will largely control the voltage impressed across parallel insulation as well as the time during which the voltage is maintained; a low internal impedance will therefore dissipate the surge energy quickly and hence will not only reduce the time of high voltage application to parallel insulation, but its magnitude as well.

These operating characteristics of a lightning arrester can be completely determined only by tests made with the Cathode Ray Oscillograph. The operation of this instrument depends essentially on the fact that a stream or pencil of electrons may be deflected either by electrostatic or electromagnetic fields and as well on the fact that such an electron stream striking a photographic plate will record itself in the same manner as a beam or pencil of light. The Oscillograph proper consists essentially of an exhausted chamber in which a photographic plate or film is enclosed, together with an electron gun arranged to project a narrow pencil of electrons onto the photographic medium. Electromagnetic deflecting coils and electrostatic deflecting plates are suitably arranged adjacent the electron stream so that fields produced thereby will deflect the stream and these deflections being recorded on the photographic plate give, after suitable calibration, an accurate record of the phenomena responsible therefor. Since the electron stream has practically no inertia, it is capable of being deflected by transients of extremely short duration and consequently photographic records of electrical phenomena occurring in a small fraction of a micro-second may be accurately recorded. The Cathode Ray Oscillograph is a most valuable tool in studying the performance of lightning arresters, it being possible to secure therewith, for example, photographic records of a lightning or high voltage surge impressed

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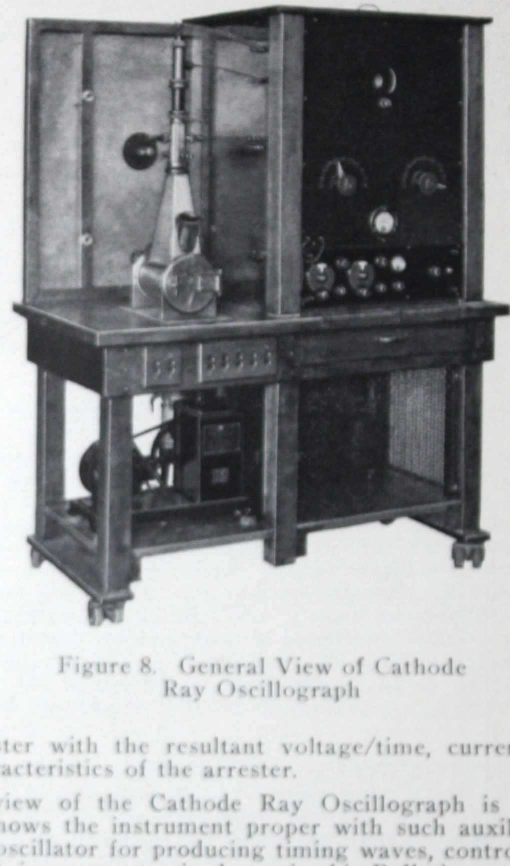

Figure 8. General View of Cathode
Ray Oscillograph

across the arrester with the resultant voltage/time, current/time and voltage/current characteristics of the arrester.

A general view of the Cathode Ray Oscillograph is shown in Fig. 8 herewith; this shows the instrument proper with such auxiliary apparatus as vacuum pumps, oscillator for producing timing waves, control equipment, etc.; a cut of our lightning generator is shown in this Bulletin, page 11.

We have made exhaustive studies of the Crystal Valve lightning arrester with the Cathode Ray Oscillograph, some typical records being reproduced herewith; the illustrations show records taken on the 3000-volt distribution type arrester, but are representative of those taken on our higher voltage types as well.

Fig. 9 shows graphically a standard test voltage surge which is impressed across the arrester; this surge is in accordance with the A. I. E. E. Proposed Standards for Lightning Arresters wherein it is specified that the rate of voltage rise prior to beginning of arrester discharge shall be at the rate of 100,000 volts per micro-second. Surge current to be used in such tests must attain a crest value of 1000 amperes; the crest value of the voltage surge necessary to produce this surge current flow through the arrester was 55,000 volts as shown; this surge voltage maintains itself as indicated in the oscillogram.

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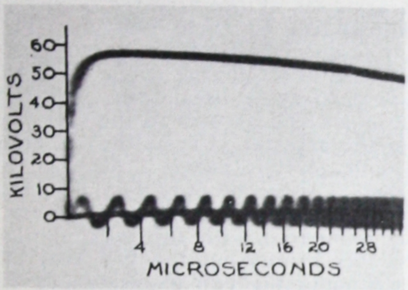

Figure 9

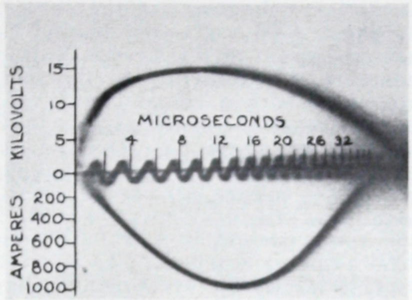

Figure 10

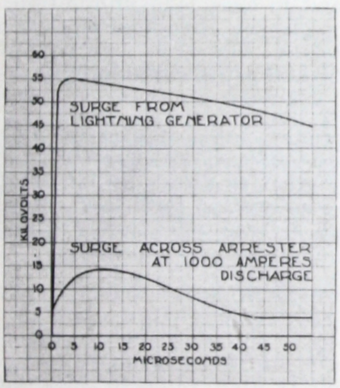

Figure 11

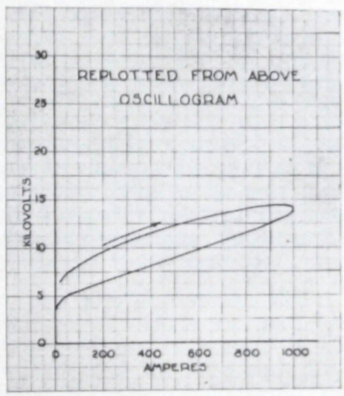

Figure 12

Fig. 10 shows to the same time axis the voltage/time and current/time characteristics of the Crystal Valve Arrester when such a standard test surge is discharged into it. Such a surge strikes the arrester and in a fraction of a micro-second has risen to the arc-over or breakdown voltage of the arrester which then spills over and begins to discharge; surge current then starts to flow through the arrester and in about 13 micro-seconds (lower curve of Fig. 10) has reached a crest value of 1000 amperes, which is the maximum current produced under these test conditions. Surge current then starts to decrease and at the end of 45 micro-seconds the valve action of the arrester closes it up and the operating cycle has been completed.

The upper curve of Fig. 10 shows the voltage conditions across the arrester during this test cycle. Note that while the rise of voltage of the test surge prior to arrester breakdown is at the rapid rate of 100,000 volts per micro-second, due to the practically negligible spark lag of the arrester, there

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type

is no "over-shooting" of the voltage wave, arc-over of the arrester occurring at about 6000 volts—practically its breakdown on 60 cycle voltage. This extreme speed of the Crystal Valve Arrester is due (as has been stated previously in this Bulletin) to the multiple system of discharge gaps used (as compared with a single gap having the same 60 cycle breakdown voltage), the design of the spark gap electrodes themselves and as well to the fact that the time lag of the characteristic element of the arrester (Crystallite) is practically negligible. Referring again to the voltage/time curve, note that the maximum voltage across the arrester reached a value of only 14.3 KV, this being reached in 11 micro-seconds. At maximum voltage across the arrester the surge current flow was 970 amperes as compared with the maximum of 1000 amperes reached in 13 micro-seconds; this brings out the fact that the voltage across the arrester and the current flowing through it are practically in phase which is a highly desirable characteristic.

Fig. 11 is a drawing made from Figs. 9 and 10 and shows graphically the voltage/time characteristics of the initial surge voltage wave, the reduction in this by the arrester and as well the time required for the complete cycle of operation. It will be noted that Figs. 9 and 10 have logarithmic time scales which were purposely used to show more clearly phenomena occurring in the first few micro-seconds of arrester operation; Fig. 11 has an equi-element time scale which makes the phenomena which it represents somewhat easier to visualize.

Fig. 12 shows a volt/ampere characteristic curve of arrester operation drawn from the oscillograms of Fig. 10. The volt/ampere characteristic curve of a lightning arrester is very important in that it shows initial breakdown voltage, sealing-up or valve voltage and in combination with the voltage/time and current/time characteristics such factors as rate of change of impedance with time, etc., may easily be figured.

A study of these several curves will now show under the test conditions outlined that the arrester arced-over and began to discharge when the surge reached a voltage of approximately 6000; in 13 micro-seconds surge current flow had reached a value of 1000 amperes; during these 13 micro-seconds the arrester impedance decreased from an infinitely high value to approximately 14 ohms; from the 13th to the 45th micro-second the current decreased from 1000 amperes to zero, the arrester impedance increasing from 14 ohms to the infinite value represented by it in its "closed valve" condition; this sealing up or valve action of the arrester occurs as seen at approximately 4000 volts.

The entire operation of the arrester has involved the two fundamental characteristics which have been explained in the forepart of this Bulletin, viz., the valve characteristic and the impedance characteristic; both actions are entirely according to unchangeable physical laws and are initiated, actuated and controlled by the characteristics of the lightning voltage impressed across the arrester; there are no chemical or physical changes occurring within the arrester; there is nothing within the arrester requiring exact structural arrangement of parts for its proper operation; its operation is analogous to that of a plain, simple safety valve which opens up at a certain predetermined voltage and whose discharge capacity varies according to the magnitude of the surge voltages and currents which the arrester must carry to ground, the discharge capacity becoming greater (the internal impedance of the arrester becoming less) as the severity of the surge becomes greater.

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Crystal Valve Type

The importance of these remarkable operating characteristics of the Crystal Valve Arrester cannot be too strongly emphasized, for not only do they result in a minimum amplitude of surge voltage impressed across parallel insulation, but in a minimum time of application as well. The amplitude of a surge voltage impressed across insulation is not in itself a criterion of the protection that will be afforded by an arrester owing to the known high impedance ratio or dielectric lag of the insulation; therefore it follows that even though the amplitude of the surge voltage is important, yet of even greater importance is the time of its application to the protected insulation; this matter of both initial and overall speed of a lightning arrester cannot be too strongly stressed in comparing the relative protective ability of this class of equipment.

The Cathode Ray Oscillograph shows the ability of the Crystal Valve to function to a more marked degree than any other modern lightning arrester as a true valve type arrester; or expressed in non-technical terms, at a given value of surge voltage to open up "wide open" in the shortest possible time, to remain wide open until the surge energy has been dissipated to earth and then to close up tight; and due to its simple principles of operation, the operating characteristics of the Crystal Valve are highly uniform over an extremely wide range of conditions.

Arresters operating on principles differing from the Crystal Valve, and particularly those types having a solid dielectric with consequent high time lag in the discharge path, do not show these uniform characteristics over wide ranges of conditions and hence afford widely varying degrees of protection depending on the characteristics of the impressed surge. Great care is necessary in interpreting Cathode Ray Oscillograph test data on such arresters as tests made under one specific set of conditions may be widely different from those obtaining under other conditions equally as important from the standpoint of actual protection afforded.

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Crystal Valve Type

Fig. 13. "Crystallite"—The Active, *Permanent* Element in the Crystal Valve Lightning Arrester

Arrester Deterioration

Two very important points in connection with lightning arresters are those relating to possible deterioration in service and those factors which influence their useful length of life. In respect to both of these the Crystal Valve Arrester is unique, as will be apparent from the following discussion.

In order for an arrester to deteriorate in service, some change must occur in the arrester, due either to operation or to ageing; the active element in the Crystal Valve Arrester is a highly refractory crystalline material to which the name "Crystallite" has been given; this material is formed at the temperature of the electric arc and is an extremely stable, practically inert, definite chemical compound. For deterioration of this active element to occur in the Crystal Valve Arrester, it would of necessity have to change in composition, due either to combination or dissociation; since the operation of the arrester is based on a true valve action no chemical changes or progressive deterioration is required for successful functioning and none is present; the most accurate observations and tests show no measurable deterioration of the Crystallite after Crystal Valve Arresters have been subjected to thousands of high voltage, high current discharges, backed up by normal line voltage. The freedom from deterioration in the Crystal Valve Arrester is directly attributable to the Crystallite used in its construction and as its most important element. As an interesting observation on the characteristics of this material, we may state that its temperature of formation is approximately 3500° F; the temperature required for dissociation is approximately 4500° F; its stability or freedom from deterioration may readily be judged by this high dissociation temperature, below which no deterioration occurs.

The other components of the Crystal Valve Arrester are principally porcelain, Isolantite, brass and copper—all materials of a highly permanent nature suffering no measurable deterioration through long continued periods of service.

It is not economically possible to test distribution arresters, except by visual inspection from the ground; an arrester that deteriorates in service is therefore a real hazard on a circuit, since such an arrester might from a visual

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type

inspection appear to be in perfect condition and in reality might be entirely inoperative and absolutely worthless from the standpoint of lightning protection.

To sum up briefly the salient points of the Crystal Valve Arrester from the standpoint of deterioration and life, we see that on account of the elements going into their construction and their principles of operation, they show no measurable deterioration and have an extremely long life; furthermore that their operation does not depend on any non-reversible chemical changes in any portion of their discharge circuit with consequent deterioration and reduction in efficiency, nor does it depend on phenomena applicable only with difficulty and uncertainty to the severe conditions encountered in lightning arrester work.

Summarized Advantages of Crystal Valve Lightning Arresters

The more important advantages of the Crystal Valve lightning arrester may briefly be stated as follows:—

a. Low initial or relief voltage for lightning disturbances.

b. High discharge rate due to the extremely low impedance of the lightning discharge path.

c. They are of the valve type and consequently employ no series resistance in the lightning discharge path: no means other than the valve action is required to either limit or extinguish a flow of power current following the lightning discharge to ground, for at normal operating voltages the flow of power current to ground is inappreciable.

d. Since the ability of an ordinary lightning arrester to function under repeated discharges is dependent largely on its ability to absorb and dissipate the heat caused by the flow of power current following the discharges to ground, it will readily be seen that owing to its valve action the Crystal Valve arrester will handle rapidly recurring lightning discharges over long periods of time without danger of destruction.

e. The Crystal Valve arrester shows no measurable deterioration after long periods of time and after having been subjected to thousands of high voltage, high-current discharges, backed up by normal line voltage.

f. This freedom from deterioration in the Crystal Valve arrester is directly attributable to the "Crystallite" used in its construction and as its most important element. "Crystallite" is a refractory crystal formed at the temperature of the electric arc and is an extremely stable, practically inert definite chemical compound. For deterioration to occur in the Crystal Valve arrester this material would of necessity have to change in composition due either to combination or dissociation; since the functioning of the arrester is based on a true valve action no chemical changes or progressive deterioration is required for successful functioning and none is present; hence the initially high efficiency of the Crystal Valve arrester maintains practically indefinitely.

g. The impedance of the Crystal Valve arrester bears an inverse ratio to the severity of the discharges which it is called upon to discharge to ground, decreasing as the severity of the discharge increases.

h. Cathode ray oscillograph tests show that their speed of operation is extremely high. This is due to the design of the spark gap electrodes with

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type

their practically negligible spark lag, and as well to the fact that in flowing through the Crystallite the discharge simply overcomes the inherent valve characteristic of the crystal contacts; there is no solid dielectric requiring puncture, with consequent time lag, in the entire Crystal Valve discharge path. It is due also to the fact that the internal impedance of the arrester is extremely low, this not only dissipating the surge energy quickly, but limiting the voltage impressed on parallel insulation to a very low value.

i. Cathode ray tests show further that since the lag of the Crystal Valve air gaps and characteristic element (Crystallite) is practically negligible, the time or speed characteristics of the Crystal Valve arrester are little affected by the steepness of the wave fronts of surges they are called upon to protect against. This important characteristic assures the utmost protection to electrical apparatus from surges with slow, average or extremely fast fronts.

j. The internal assembly of the Crystal Valve arrester is such that possible radio interference has been entirely overcome. While the Crystal Valve arrester primarily has been designed to afford lightning protection to electrical apparatus, it is of more than ordinary interest to prospective purchasers to know that careful consideration has been given to the increasingly important problem of radio interference.

k. By reference to dimensional diagrams on page 27, it will be seen that Crystal Valve arresters are relatively small and may be installed on a transformer pole without overcrowding; installed in this manner they assure maximum protection.

l. They require no inspection other than a visual inspection from the ground. This is a requisite of a good arrester, as where large numbers are installed inspection costs are reduced to a very small item.

m. Their first cost and cost for installation is so low that they may economically be used to protect every transformer on a system, and as well may be used for line service where the density of transformer installations is so low that added protection for the lines is warranted.

n. The bodies and caps of all Crystal Valve arresters are made from the highest grade wet process porcelain.

o. The arresters have extremely long life, because of the fact that the elements going into their construction are of a permanent nature and do not measurably deteriorate through long continued periods of service; these elements are principally porcelain, Crystallite, Isolantite and brass—all materials of great endurance. Their operation does not depend on any non-reversible chemical changes in any portion of their discharge circuit, with consequent deterioration and reduction in efficiency, nor does it depend on phenomena applicable only with difficulty and uncertainty to the severe conditions encountered in lightning arrester work. A simple, positive and durable electrical safety valve of very large capacity—"The Crystal Valve Arrester."

Installation

Crystal Valve arresters may be fully employed in protecting all classes of electrical apparatus, and particularly where "100 per cent. protection" is desired; that is, where every transformer on a circuit is protected. They may also be freely used for line installation where the density of transformer installations is so low that added protection for the lines is warranted. (See discussion of this matter on page 3.)

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Crystal Valve Type

When protecting transformers or other apparatus installed on ungrounded circuits, one arrester should be installed on each line wire, the ground wires tied together and run to a common ground. They should, whenever possible, be installed on transformer poles where protecting this class of apparatus, and, generally speaking, should be installed close to any apparatus which they are to protect.

When protecting transformers on dead grounded neutral circuits, one arrester should be installed on the line wire; a tap from the grounded wire and the ground wire from the arrester should be tied together and run to a common ground.

When protecting transformers on grounded neutral circuits, when the neutral wire is grounded only at power or sub-stations, one Crystal Valve Arrester should be installed on the line wire and a small spark gap arrester connected between the neutral wire and earth. Ground wires from the two may be tied together and run to a common ground. Several types of Neutral Arresters suitable for this purpose are listed and described on following pages.

Grounding

Grounding Crystal Valve Arresters is no different from grounding other arresters. All grounds should be good and should be maintained in good condition if full efficiency is to be expected from the lightning arrester installation. *Bear in mind that lightning arresters can't have too good a ground.*

Among the general rules for grounding Crystal Valve Arresters may be mentioned the following:

1. Provide short, straight wires from line to arrester and from arrester to ground. Wire of No. 6 B&S gauge or larger should be used in all cases.
2. When a turn is necessary, avoid sharp angles by carrying the wire in a curve of long radius.
3. The arrester should be installed in a vertical position *with the capped end up.*
4. Solder carefully and tape all joints and connections.
5. Run all arresters installed on the same pole to a common ground wire.
6. Soldered joints underground should be given a coat of preservative paint.
7. For further and more complete information on this subject reference should be made to a new 48 page hand-book which we have just issued entitled "Lightning Arrester Grounds." This is perhaps the most complete, practical booklet published on this subject and will be of great interest and assistance to everyone interested in this phase of lightning protection; copies will be sent upon request.

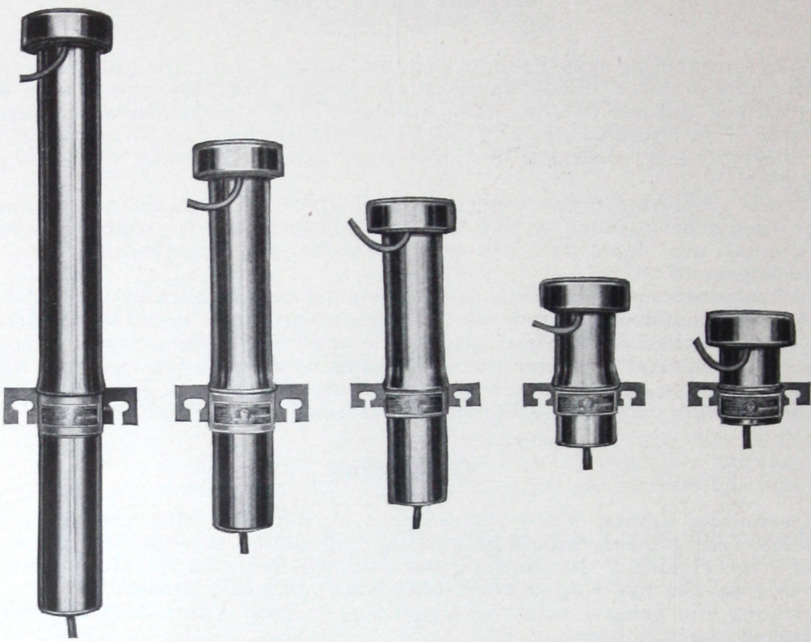
See page 59 of this Bulletin for listing of ground fittings.

Inspection

No inspection of a Crystal Valve Arrester other than a visual inspection from the ground is necessary. Being entirely self-contained one can see at a glance whether or not it is in good condition and on account of its features of non-deterioration a Crystal Valve Arrester which from such inspection appears to be in good condition may safely be assumed to be such. This is a decidedly good feature, as where large numbers of them are installed, inspection costs are reduced to a very small item.

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type—350-15000 Volts A. C.



Crystal Valve Lightning Arresters for 350-15,000 Volt A. C. Service
(See p. 30 for 25,000 V. Arrester)

Keystone Crystal Valve Lightning Arresters represent an outstanding development in the successful application to lightning protective apparatus of the rectifying properties and valve characteristics of certain refractory conductive crystals. Previous attempts that have been made to utilize these properties commercially have been only partially successful, owing to the difficulty in building the valve cut-off voltage sufficiently high for present-day operating voltages and at the same time keeping the impedance of the crystalline mass to a value low enough to afford protection against lightning discharge currents of relatively high value.

Through intensive researches in this field this Company has been able to develop crystals of such composition and structure that not only can a given arrester be designed and built with any predetermined valve cut-off voltage, but as well an impedance secured which is of an extremely low value.

Crystal Valve Lightning Arresters are entirely self-contained, being housed in glazed porcelain bodies and supplied with galvanized iron hangers for attachment to suitable supporting means. A portion of the interior of the body is packed with "Crystallite"—the special crystalline element before mentioned—in series with which are one or more spark gaps, between high-speed electrodes; these gaps are proportioned to the operating voltage for which the arrester is designed and as well to the valve cut-off voltage of the Crystallite element. Both the valve cut-off voltage and the arrester discharge voltage are determined largely by the peak value of maximum rated line voltage, these factors being so adjusted that the arrester functions upon slight voltage rises, thus assuring highly efficient protection.

In operation, lightning discharges simply arc over the air gaps and flow to ground across the air gaps and through the Crystallite, which, as before

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type—350-15000 Volts A. C.

stated, offers a path of extremely low impedance to their passage. Since the arrester is of the valve type, and since the valve cut-off voltage is set somewhat in excess of the maximum voltage rating of the arrester practically no line current follows the lightning discharge to ground, hence in operation the arrester acts simply as a safety valve for excess voltages built up on the line.

Voltage Ratings

Crystal Valve Arresters are grouped into voltage ratings which efficiently cover the usual standard voltage ratings of distribution circuits. Efficient valve type arresters are sensitive to continuously applied circuit voltage above their maximum rating and while we have provided a very liberal factor of safety in the value of the critical voltage above the maximum voltage rating of the arrester, yet for efficient and satisfactory performance it is necessary that when installed the maximum circuit voltage shall not exceed the maximum rated voltage of the arrester. A table giving complete information regarding the voltage ratings of these arresters will be found on page 26.

All published ratings apply only for altitudes up to 4000 feet. For altitudes above 4000 feet special recommendations will be made.

Mounting Brackets

Crystal Valve arresters may be obtained with either of four types of mounting bracket, complete data on same being given on pages 28 and 29. Unless otherwise specified on order, arresters Forms D, 1, 3 and 7 will be supplied with the Type CA bracket; arresters Forms 8 and 10 will be supplied with the Type DA bracket. All brackets, together with bolts, nuts and washers are of hot galvanized steel. All galvanizing will meet the National Electric Light Association specifications.

Dimensions

Diagrams and data on page 27 give complete dimensional information on the entire line of Crystal Valve Arresters fitted with the CA and DA types of mounting brackets; these dimensions are for reference only and are subject to change; blue prints giving official dimensions will be furnished upon request as will also prints showing any of the arresters fitted with any of the mounting brackets listed.

Leads

All Crystal Valve Arresters are regularly provided with line and ground leads of No. 6 B&S gauge stranded cable, 18 inches long, except the Type CV form D which is regularly supplied with 36-inch line lead and 18-inch ground lead.

Price Listing

Table on page 26 gives List Number, Type, Standard Package Quantity and List Price on the entire line of Crystal Valve Arresters; unless otherwise specified on order arresters Forms D, 1, 3 and 7 will be supplied with Type CA bracket; arresters Forms 8 and 10 will be supplied with Type DA bracket.

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type—350-15000 Volts A. C.†

Voltage Ratings*

	Type	Table 1 For Delta or Ungrounded Y Three-Phase Systems	Table 2 For Three-Phase Y Systems with Solidly Grounded Neutral
50935	CV Form D	350-1000 Volts	....
50925	CV Form 1	1000-3000 "	....
50927	CV Form 3	1000-3000 "	3000-5000 Volts
50931	CV Form 7‡	3000-6000 "	5000-9000 "
50932	CV Form 8	6000-9000 "	9000-12,800 "
50934	CV Form 10	9000-15,000 "	12,800-18,000 "

All voltages specified are maximum *phase-phase* voltages.

For straight single phase circuits use arresters recommended in Table 1.

Treat single phase circuits split from two phase, and single and two phase circuits split from three phase circuits in accordance with the recommendations covering the particular type of circuit from which they are split.

For two phase four wire ungrounded circuits use arresters recommended in Table 1. For two phase three wire circuits with ungrounded neutral use arresters recommended in Table 1 for the phase wires; for the neutral wire use arresters rated at 71 per cent of the phase-phase voltage.

For the neutral wire of three phase four wire ungrounded Y circuits use arresters rated at 58 per cent of the phase-phase voltage.

For neutral protection on either two or three phase circuits where the neutral is solidly grounded, use Type T-300, N or NS arresters as listed on following pages; if, due to unbalancing, the voltage between neutral and ground is between 350 and 1000 volts, use type CV form D arrester, listed below.

The list numbers below cover the various arresters complete with either type CA or DA mounting bracket; if arresters are to be supplied with any of the other types of brackets illustrated on pages 28 and 29, order must clearly specify *both* the above list number of the arrester *and* the type of the bracket desired. Arresters are supplied with any of these brackets at the standard list prices.

List No.		Std. Pkg.	List Price Each
50935	Type CV form D arrester	12	$6.75
50925	Type CV form 1 arrester	12	10.50
50927	Type CV form 3 arrester	12	10.50
50931	Type CV form 7 arrester	6	19.25
50932	Type CV form 8 arrester	6	27.20
50934	Type CV form 10 arrester	3	45.25

* *Voltage ratings given apply only for installations at altitudes up to 4000 feet. For altitudes above 4000 feet special recommendations will be made.*

† *For Crystal Valve arresters for 15,000-25,000 volt service see description and listing on pages 30 and 31.*

‡ *A special Crystal Valve lightning arrester, the type CV form 4, has been developed for railroad signal transmission circuits normally operating at 4400 volts. This is described and listed on page 53.*

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type—350-15000 Volts A. C.

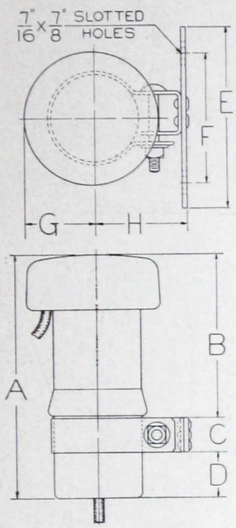


Fig. 1
Nos. 50935
50925
50927
50931
With Type "CA"
Mounting Bracket

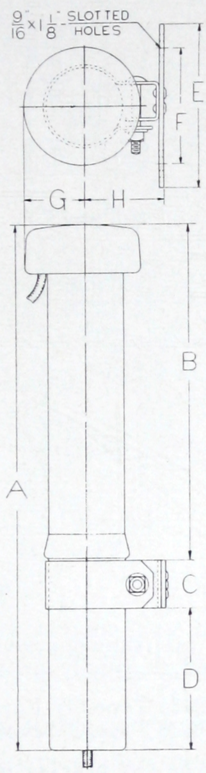


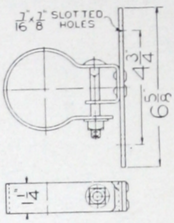
Fig. 2
Nos. 50932
50934
With Type "DA"
Mounting Bracket

Dimensional Data

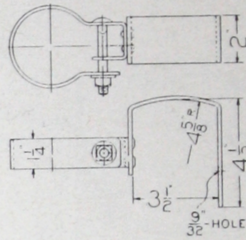
		Dimensions in Inches							
Cat. No.	Fig.	A	B	C	D	E	F	G	H
50935	1	6	4⅜	1¼	⅜	6⅝	4¾	2 9/16	3 5/16
50925	1	9	6⅛	1¼	1⅝	6⅝	4¾	2 9/16	3 5/16
50927	1	9	6⅛	1¼	1⅝	6⅝	4¾	2 9/16	3 5/16
50931	1	16⅛	10¼	1¼	4⅝	6⅝	4¾	2 9/16	3 5/16
50932	2	20⅜	13¼	2	5⅛	6¾	4¾	2 9/16	3 5/16
50934	2	31¼	20	2	9¼	6¾	4¾	2 9/16	3 5/16

KEYSTONE LIGHTNING ARRESTERS

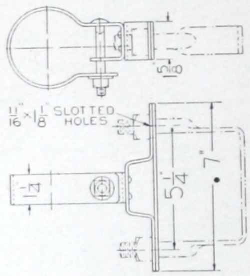
Crystal Valve Type—350-6000 Volts A. C.



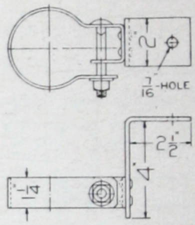
Type CA



Type CB



Type CD



Type CE

Mounting Brackets

Above are shown drawings of the four types of mounting brackets we are prepared to supply on the following Crystal Valve Lightning Arresters:

No. 50935 Type CV Form D	No. 50927 Type CV Form 3
No. 50925 Type CV Form 1	No. 50931 Type CV Form 7

The Type CA bracket is designed for cross arm or flat surface mounting and is the type generally preferred by the user. The Type CB is a saddle type bracket for the standard 3½x4½ inch cross arm and is made only in the size shown. The Type CD is a clamp type bracket designed for use with standard Pierce cross arm straps and may be used with either the No. 1001-2-3-4 or 2001-2-3 or 4 Pierce straps; the Pierce straps are not included as a part of the bracket. The Type CE is a semi-saddle type bracket bolting to the top of the arm and may be used with any standard arm.

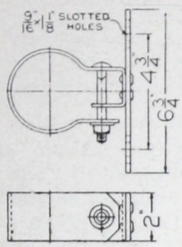
All brackets are made from heavy steel stock, hot galvanized; bolts, nuts and washers are likewise hot galvanized; mounting members are attached to the arrester clamping member both by riveting and spot welding and the entire assemblies are such that brackets of great strength, durability and ease of application are provided. All galvanizing will meet the National Electric Light Association specifications.

When Crystal Valve Arresters are ordered by the List Number and/or Type only as given in the Listing on page 26, the Type CA mounting bracket will be supplied. Where the Type CB, CD or CE bracket is desired instead of the Type CA it is necessary to clearly specify on order *both* the List Number or Type Arrester desired *and* the Type Number of the bracket.

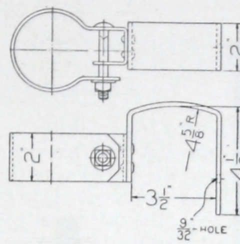
Arresters are supplied with any of these four mounting brackets at the standard List Prices given on page 26.

KEYSTONE LIGHTNING ARRESTERS

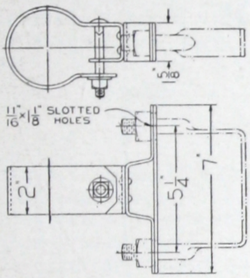
Crystal Valve Type—6000-15000 Volts A. C.



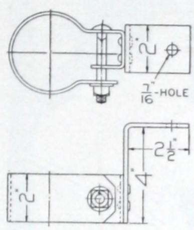
Type DA



Type DB



Type DD



Type DE

Mounting Brackets

Above are shown drawings of the four types of mounting brackets we are prepared to supply on the following Crystal Valve Lightning Arresters; these are made from heavier stock than the types shown on preceding page for these larger and heavier arresters:

No. 50932 Type CV Form 8   No. 50934 Type CV Form 10

The Type DA bracket is designed for cross arm or flat surface mounting and is the type generally preferred by the user. The Type DB is a saddle type bracket for the standard 3½x4½ inch cross arm and is made only in the size shown. The Type DD is a clamp type bracket designed for use with standard Pierce cross arm straps and may be used with either the No. 1001-2-3-4 or 2001-2-3 or 4 Pierce straps; the Pierce straps are not included as a part of the bracket. The Type DE is a semi-saddle type bracket bolting to the top of the arm and may be used with any standard arm.

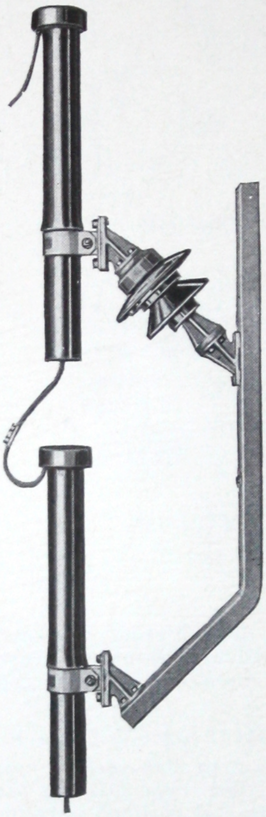
All brackets are made from heavy steel stock, hot galvanized; bolts, nuts and washers are likewise hot galvanized; mounting members are attached to the arrester clamping member both by riveting and spot welding and the entire assemblies are such that brackets of great strength, durability and ease of application are provided. All galvanizing will meet the National Electric Light Association specifications.

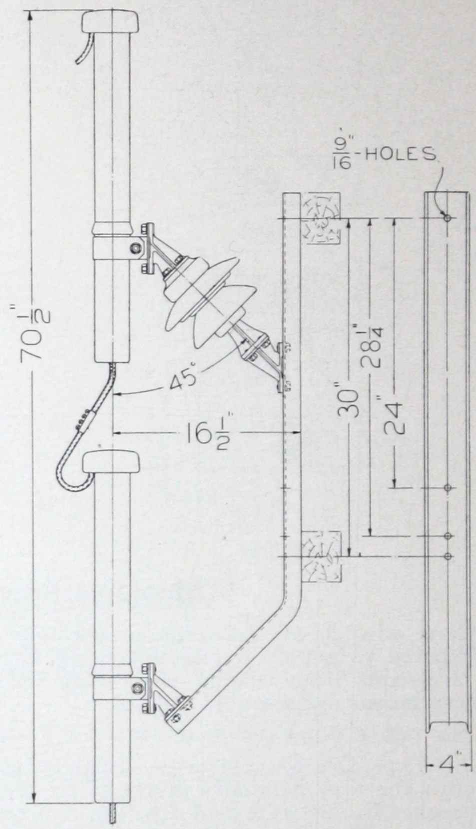
When Crystal Valve Arresters are ordered by the List Number and/or Type only as given in the Listing on page 26, the Type DA mounting bracket will be supplied. Where the Type DB, DD or DE bracket is desired instead of the Type DA it is necessary to clearly specify on order *both* the List Number or Type Arrester desired *and* the Type Number of the bracket.

Arresters are supplied with any of these four mounting brackets at the standard List Prices given on page 26.

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type—15000-25000 Volts A. C.





The type CV form 11 Crystal Valve lightning arrester illustrated above and rated for use on systems operating at from 15,000 to 25,000 volts, operates on principles identical with those inherent to the lower voltage Crystal Valve arresters, and consequently possesses the same features of high efficiency, reliability and freedom from deterioration; these features have all been covered at length in the preceding pages.

For convenience in manufacture, shipment and installation, the arrester proper is made in two body sections as shown, both of which are attached to a standard 4-inch channel iron base member. The upper or line unit is attached to this base through the medium of a 35,000-volt insulator, while the lower or ground unit is directly attached to the base by means of the clamping band and angle bracket as shown. The line unit is provided with an 18-inch lead of No. 6 B&S gauge stranded cable for connection to the line, while a similar lead is provided on the ground unit for connection to earth. The two body sections or units are electrically connected in series as shown by means of a 4-screw cylindrical brass connector. Bodies and caps are made of the

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type—15000-25000 Volts A. C.

highest grade wet process porcelain, while all hardware, including bolts and nuts, is made of steel or iron, heavily hot galvanized. All galvanizing will meet the National Electric Light Association specifications.

Arresters are shipped in knockdown form and are accompanied with prints showing clearly the method of reassembling for service. After reassembly they may be installed in any convenient manner, the preferred location being as near as possible to the apparatus which they are used to protect; they should be installed vertically with the line unit up; the several $\frac{9}{16}$-inch holes in the channel base are so located as to cover several more or less standard cross arm spacings where such means of support is employed.

The dimensions given on preceding page are for reference only and are subject to change; blue prints giving official dimensions will be furnished upon request.

Voltage Rating

The type CV form 11 Crystal Valve arrester is designed for application to systems having *phase to phase* voltages of from 15,000 to 25,000; these include Delta systems, Y systems with solidly grounded neutral, and Y systems with non-grounded neutral. On a 4-wire non-grounded Y system, the type CV form 11 arrester should be used on the phase wires while the type CV form 10 arrester should be used on the neutral. On 4-wire Y systems with solidly grounded neutral, for neutral protection use Type T-300, N or NS arresters as listed on following pages; if, due to unbalancing, the voltage between neutral and ground is above 350, use any of the previously listed Crystal Valve arresters rated for the maximum voltage existing between neutral and ground.

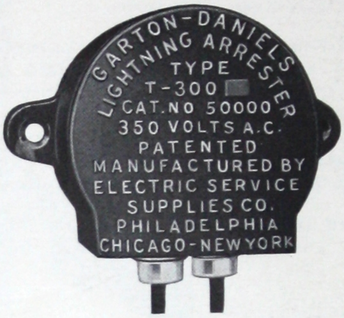
The above ratings apply only for installations at altitudes up to 4000 feet. For altitudes above 4000 feet special voltage ratings will be given upon request.

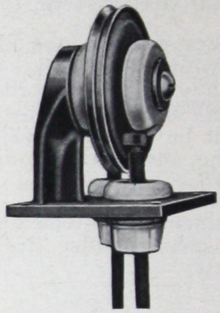
List No.		Std. Pkg.	List Price Each
51001	Type CV form 11 arrester	3	$148.00

GARTON-DANIELS LIGHTNING ARRESTERS

Type T-300, Up to 350 Volts A. C.

(Also for Neutral Protection)





Type T-300 lightning arresters are for use on any A. C. circuits of 350 volts or less, and are particularly recommended for series incandescent lighting circuits, for the protection of individual arc lamps by shunting them around the terminals as well as for the protection of apparatus such as motors or transformers connected to such circuits. They are also used in large numbers for protecting the neutral wire of transformers installed on grounded neutral circuits, where the neutral wire is grounded only at power or sub-station, and not dead grounded at the transformer installation, voltage between neutral and ground not exceeding 350.

In construction they consist simply of two heavily-beaded brass discs, separated far enough by a high resistance block to allow an air gap distance of 1/50 inch (.020 inch) between the discs.

The interior, suitably assembled with mica, porcelain, etc., is mounted in a well-made iron box, as shown in above illustrations.

Light static discharges find a path to earth through the high resistance block separating the discs. Heavier discharges pass across the small air gap.

For extinguishing the flow of normal current following the discharge to ground, no means other than the arc extinguishing properties of the air gap are necessary. This assures a positive cut-off of this current flow at the zero point of the generator voltage wave after the discharge has passed to ground.

Type T-300 arresters are low-priced and will be found particularly suitable for many classes of work.

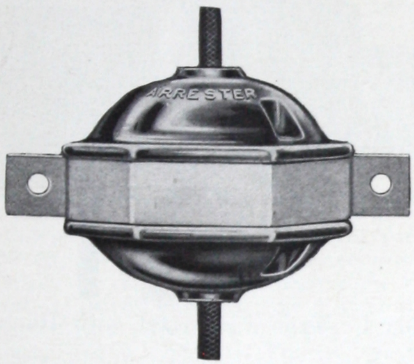
Dimensional diagram is given on page 41.

List No.		Std. Pkg.	List Price Each
50000	Type T-300 Garton-Daniels lightning arrester, for voltages up to 350 A. C.	12	$4.00

KEYSTONE LIGHTNING ARRESTERS

Type N—For Neutral Protection

(Voltage to Ground 350 or less)



Type N arresters are designed for protecting the neutral wire of transformers installed on grounded neutral circuits, where the neutral wire is grounded only at power or sub-station, and not dead grounded at the transformer installation.

They are of the self-contained type, consisting of non-arcing metal electrodes, separated by a small air gap, the whole being enclosed in a glazed porcelain body. They are supplied with an iron band which slips over the arrester body, so allowing same to be attached to the cross arm or other supporting means. As shown in illustration above, line lead enters the top of the arrester, ground lead leaving the bottom; both leads are securely cemented into the arrester, and as an added precaution against water leaking in through these seals, a metallic rain shield is attached to the upper or line lead inside the arrester, so effectively shielding the gap and preventing short-circuits from leaks. While these arresters have been designed especially for neutral protection they may be used with equal success for protecting apparatus on any type of A. C. circuit the voltage to ground of which does not exceed 350.

These arresters are cheap, simple, durable, of high efficiency, easy to install and inspect; maximum height is $2\frac{5}{8}''$; depth or width, $3\frac{3}{16}''$. Iron strap for supporting the arrester has two $\frac{9}{32}''$ holes spaced on $3\frac{3}{4}''$ centers. Line and ground leads are of No. 12B&S gauge cable, 12 inches long.

Type NS is the same as type N, but supplied without supporting band where arrester is intended to be hung directly from neutral wire.

Dimensional diagram is given on page 41.

List No.		Std. Pkg.	List Price
50642	Type N Neutral Arrester	24	$2.00
50643	Type NS Neutral Arrester (Same as Type N, but supplied without supporting band where arrester is intended to be hung directly from neutral wire)	24	1.90

LIGHTNING PROTECTION FOR SECONDARY CIRCUITS

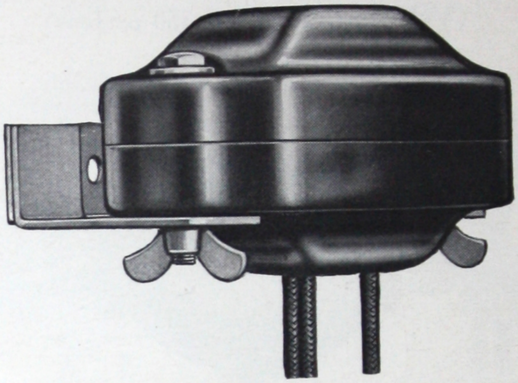


Fig. 1. Type S Arrester with Hanger

Low voltage secondary circuits at the present time are almost entirely without lightning protection; the fact that these circuits are relatively short and are not highly insulated from ground has led to the assumption that they were little subject to lightning disturbances, and on this account it has generally been felt that lightning protection was not required.

The increasing value which the modern Central Station places on reliable and continuous service has led several of the larger ones to undertake very exhaustive studies in connection with the subject of lightning protection for their distribution transformers; several of these studies and investigations have been carefully carried along for a number of years and since they have involved records of many thousands of transformers the data secured has been of a high order of accuracy and the conclusions arrived at have been accepted as authoritative by the Central Station field in general. Heretofore most of these studies have dealt largely with the protection of the primary sides of the distribution transformers with lightning arresters and have led to the modern standard practice of protecting the high side of every transformer with lightning arresters installed preferably on the transformer pole. This practice has resulted in very greatly reducing the number of transformers burned out during lightning storms, as well as the number of fuses blown, and so has resulted not only in reduced expense for replacing transformers and fuses, but has greatly improved the service rendered consumers.

Since one of the ideals sought by the modern Central Station is to render absolutely continuous service and since even with every transformer protected on the high side with lightning arresters some were still burned out during lightning storms, with consequent service interruption, more critical studies of transformer protection have been undertaken with the purpose in mind of determining the possibly few remaining reasons underlying the destruction of transformers by lightning, thereby enabling further steps to be taken to guard against them and in such manner still further improving the quality of service rendered the consumer.

From such detailed and analytical studies it has been found that a considerable percentage of the total transformer failures on a system where every transformer has its high side protected with lightning arresters may be directly chargeable to lightning entering the transformer over the unprotected secondary circuits. A surprising fact in this connection is that the length of secondary circuits apparently has little effect, for transformers have failed in

KEYSTONE LIGHTNING ARRESTERS

For Secondary Protection

this manner where the length of secondary circuit did not exceed 100 feet.

A thorough examination of a number of burned out transformers, including complete unwinding of the coils, is necessary to determine the point of lightning entrance and the path which the lightning followed to ground; such an investigation will generally determine these points and will enable one to determine whether or not the damage might have been prevented had suitable lightning arresters been installed before the burn-out had occurred.

Many burned-out transformers have been so analyzed and it has been found that where lightning has entered the secondary wiring failure has occurred in either one or more characteristic ways. Such an analysis recently made on a number of transformers so destroyed showed for example that on 31.5 percent lightning entered over a secondary phase wire, broke down secondary insulation to core and case, then arcing over the secondary neutral bushing went to ground over the grounded secondary neutral wire. On 31.5 percent lightning entered over a secondary phase wire and puncturing the insulation within the coils to the grounded secondary neutral wire flowed to ground. On 21 percent lightning entered over a secondary phase wire, punctured the insulation within the coils to a primary phase wire, then flowed to ground over the primary phase arrester. On 10.7 percent lightning entered over a secondary phase wire, broke down secondary insulation to core and case, then arced over a primary phase bushing to the primary phase wire, flowing to ground through the primary phase arrester. On the remaining 5.3 percent lightning entered over a secondary phase wire, broke down secondary insulation to core and case, then broke down the insulation from core to primary coil, flowing to ground over the primary phase arrester.

In all of these cases it is apparent that a lightning disturbance originating on the secondary phase wires was responsible for the transformer failure and that a very large percentage of them could have been prevented had the secondaries been protected with efficient lightning arresters, properly installed.

The examples cited above cover only those cases of transformer failure where same could quite accurately be laid to lightning actually entering over the secondary wiring; in studying and analyzing burned out transformers there are always a number of cases where failure cannot properly be laid to lightning definitely entering either the primary or the secondary wiring; some such indeterminate cases may very properly be assumed to have been caused by lightning entering the secondary wiring, and a large percentage of these can then very properly be classed as avoidable had the secondaries been equipped with lightning arresters; as a matter of fact, since the primary sides of distribution transformers are almost generally protected with lightning arresters it is reasonable to assume that a larger proportion of indeterminate failures may be chargeable to lightning entering over unprotected secondary wiring than over protected primary wiring, and consequently reasonable to assume that a large proportion of the indeterminate transformer failures would be prevented were the secondaries properly protected with lightning arresters.

Besides greatly reducing the number of transformers burned out by lightning, secondary lightning arresters afford protection to watt-hour meters and other low voltage apparatus connected to the service lines; they also greatly reduce the number of primary fuses blown by preventing secondary bushing flash-over with the consequent secondary short-circuit responsible for the primary fuse failure.

This Company realizing the need for a really satisfactory and efficient low voltage secondary lightning arrester has developed its Type S arrester, which is illustrated herewith. Fig. 1 shows a general view of the arrester complete with hanger; Fig. 2 shows a sectional view from which its construc-

KEYSTONE LIGHTNING ARRESTERS

For Secondary Protection

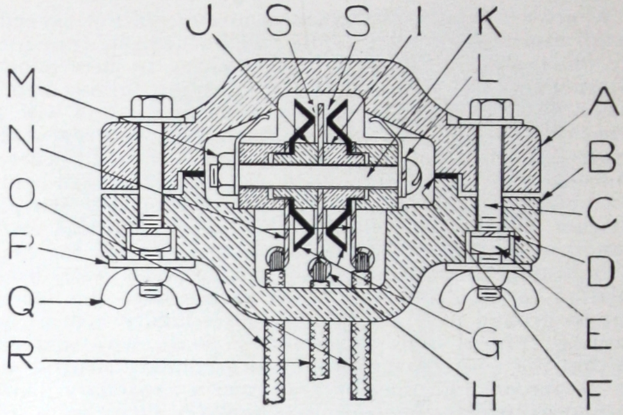


Fig. 2. Sectional Diagram

tion and operation will be clearly apparent; Fig. 3 shows the arcing unit removed from body; Fig. 4 shows assembly of arrester in body, with upper section of body removed.

The arrester consists of a two sectioned glazed porcelain casing, upper section "A," lower section "B," which with the arrester element enclosed are tightly bolted together by bolt "C" and lock washer and nut "D" and "E"; the cork gasket "F" together with the contour of the porcelain surfaces serves to make the interior of the casing thoroughly weatherproof.

The arrester element or arcing unit consists of two heavy brass discharge electrodes "G"—which are of the high speed type and identical with those used by us for many years in the Crystal Valve and Keystone Expulsion Arresters for higher voltage circuits—and a flat brass plate electrode "H" assembled with genuine Bakelite spacers "I" and "J" of suitable thickness to give the required air gaps "S" and "S" and to thoroughly insulate these electrode elements from the tie bolt "K," which with lock washer "L" and nut "M" serves to rigidly and securely clamp these discharge electrodes together. Lugs "N" securely clamped as above into contact with discharge electrodes "G" carry the line leads "O" into electrical contact with the electrodes, while the ground lead "R" is soldered directly into a terminal provided integral with ground electrode "H."

The arrester is supported by the hanger "P," which slips over extended ends of the bolts "C" and is clamped thereto by means of wing nuts "Q."

In operation lightning discharges enter the arrester via the line leads "O" and jumping the small spark gaps "S" flow to ground through ground electrode "H" and ground lead "R." For extinguishing any flow of dynamic or follow current that may follow the lightning discharge to ground, no means other than the arc extinguishing properties of the air gaps are necessary. This assures a positive cut-off of this current flow at the zero point of the generator voltage wave after the lightning discharge has passed to ground.

The Type S Keystone Secondary Lightning Arrester has a number of distinctive and decided advantages which recommend it most highly to those desiring thoroughly efficient and reliable secondary circuit lightning protection. Several of these advantages may be enumerated as follows:

(1) It is of the double pole type providing protection for both phase wires

KEYSTONE LIGHTNING ARRESTERS

For Secondary Protection

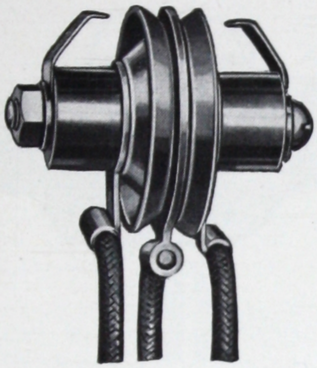


Fig. 3. Arcing Unit

in standard 110/220, 115/230, 120/240 volt services.

(2) It is of the air gap type, the discharge path consisting of only a small air gap between heavy brass high speed electrodes of the type that have proven so successful in our Crystal Valve and Expulsion arresters.

(3) The fact that no series resistance or provision for securing valve action is required on arresters for this voltage rating enables the discharge path to be constructed as above described; consequently it is of very high efficiency and affords the utmost protection to apparatus.

(4) Insulating members separating discharge electrodes are of genuine Bakelite, first moulded to approximate dimensions and then finished by means of a diamond cutting tool to a high degree of accuracy. This high accuracy of the insulating spacers, plus the highly accurate forming and sizing of the discharge electrodes means that very exact air gap adjustment and consistent performance will obtain.

(5) The design of the arrester is such that the entire arcing unit, including line and ground leads, is completely assembled before it is enclosed in the porcelain housing. This permits actual checking of the finished mechanical and electrical properties of the arrester element before sealing up.

(6) The arrester is enclosed in a glazed two piece porcelain cover, securely gasketed and made weatherproof. It is arranged to be mounted on the cross arm or other suitable support by means of a heavily galvanized strap iron hanger.

(7) The hanger is so designed that it may first be screwed or bolted to the cross arm or other suitable support, after which the arrester is placed on the bracket and securely clamped to it by means of two wing nuts threading onto the exposed ends of the two arrester bolts. This greatly facilitates the installation of the arrester and eliminates the possibility of cracking the porcelain body as so often obtains where the porcelain is directly attached to the supporting means by bolts or lag screws.

(8) Since the arrester consists entirely of elements that are of a permanent and enduring nature, porcelain, Bakelite, brass or copper, it has an extremely long life.

(9) They are small in size and consequently may be readily installed on a transformer pole without overcrowding; installed in this manner they assure maximum protection. They may also be installed on customer's premises to protect motors or other apparatus. Since all parts of the arrester are thor-

KEYSTONE LIGHTNING ARRESTERS

For Secondary Protection

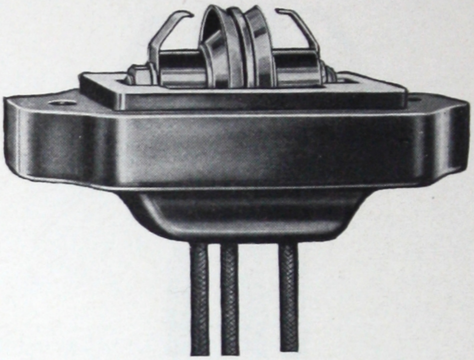


Fig. 4. Arcing Unit in Lower Porcelain Member

oughly insulated and it is constructed of non-inflammable material, it is perfectly safe to install in a customer's house or building wherever such installation may be desirable.

(10) They require no inspection other than a visual inspection from the ground. This is a requisite of a good arrester, as where large numbers are installed inspection costs are reduced to a very small item.

(11) Their first cost and cost of installation is so low that they may economically be used to protect every transformer on a system and as well may be used for protecting other apparatus on secondary services where the investment or service value of the apparatus will justify the slight expenditure necessary for protection.

(12) They are packed in individual sealed cartons, not only making them convenient for bin storage, but as well protecting them from the time they leave the factory until they are placed in actual service.

Installation

Type S Keystone Secondary Lightning Arresters have been designed particularly for the protection of the secondaries of distribution transformers supplying standard 110/220, 115/230, 120/240 volt three wire grounded neutral secondary services; consequently they are of the double pole type. In installing, the two outside leads, marked "L" on the porcelain body are connected to the outside phase wires; the middle lead, marked "G" on the porcelain body, is connected to ground.

It is generally inadvisable to ground the secondary arrester to the same ground to which the primary lightning arresters are connected owing to the possibility of lightning potentials being impressed on the secondary circuit due to a possible high resistance of the primary arrester ground; it is therefore recommended that the ground lead from the secondary arrester be connected either to a separate ground which may be driven at the transformer pole, or instead of this the ground lead may be connected only to the grounded secondary neutral wire.

This latter method of installation is generally preferred on account of its practically negligible cost as compared with the former, and while it introduces some impedance in the ground circuit due to the length of secondary wire generally in the circuit between the lightning arrester and the first secondary ground, yet the loss in efficiency of the arrester due to this impedance

KEYSTONE LIGHTNING ARRESTERS

For Secondary Protection

is practically nil, being compensated for by the extremely low resistance always obtaining between the well grounded secondary neutral and earth.

The arrester should be installed as close to the transformer as possible, preferably on the transformer pole.

Where the arrester is installed to protect service motors, meters and other electrical apparatus supplied from three wire grounded neutral circuits, it should be installed as close to the apparatus as possible, the line leads "L" being connected to the phase wires and the ground lead "G" being connected to the grounded neutral.

Where one 115 volt circuit, consisting of one phase wire and a grounded neutral, is to be protected, connect either of the "L" leads to the phase wire and the "G" lead to the grounded neutral wire. Cut off the other "L" lead at the arrester.

The arrester may be used to protect apparatus installed on a 230 volt circuit consisting of one phase wire and a grounded wire by connecting one of the "L" leads to the phase wire and the other "L" lead to the grounded wire. Cut off the "G" lead at the arrester.

In protecting apparatus installed on a two wire 115 volt circuit or on a two wire 230 volt circuit, ungrounded, connect the "L" leads to the circuit wires; the "G" lead should then be connected to a standard lightning arrester ground installed especially for this purpose and not used in grounding primary lightning arresters.

Grounding

The making of earth grounds where such are required for lightning arresters on secondary circuits is no different from the making of grounds for arresters on other classes of circuits; all grounds should be good and should be maintained in good condition if full efficiency is to be expected from the lightning arrester installation. Bear in mind that lightning arresters can't have too good a ground.

Among the general rules for grounding Keystone Type S Secondary Lightning Arresters may be mentioned the following:

1—Provide short, straight wires from line to arrester and from arrester to ground.

2—Where a turn is necessary, avoid sharp angles by carrying the wire in a curve of long radius.

3—Install the arrester in a horizontal position with the wires coming out of the bottom of the body.

4—Solder carefully and tape all joints and connections.

5—Joints underground should be given a coat of preservative paint.

For very complete information on making and maintaining lightning arrester grounds, see our Bulletin "Lightning Arrester Grounds." Copies will be sent upon request. See page 59 of this Bulletin for listing of fittings.

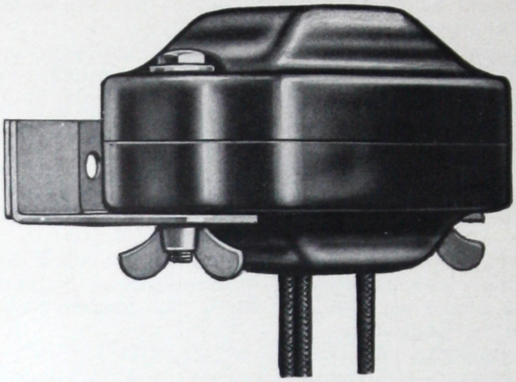
Inspection

No inspection of a Keystone Secondary Arrester other than a visual inspection from the ground is necessary. Being entirely self-contained one can see at a glance whether or not it is in good condition and on account of the fact that it suffers practically no deterioration an arrester which from such inspection appears to be in good condition may safely be assumed to be so. This is a decidedly good feature, as where large numbers of them are installed, inspection costs are reduced to a very small item.

KEYSTONE LIGHTNING ARRESTERS

Type S—For Secondary Protection

Up to 350 Volts A. C.



Type S Lightning Arrester

Keystone Type S Lightning Arresters are designed particularly for the protection of 110/220, 115/230, 120/240 volt A. C. secondary circuits, though they may be used for protecting other apparatus on either two or three wire circuits where the maximum voltage between conductors does not exceed 350.

They are made only in double pole type as illustrated and consist essentially of heavy non-arcing metal electrodes forming small air gaps between each line and ground. These are suitably assembled into a self-contained arcing unit assembly which is then housed in a glazed porcelain case. Lightning discharges find a path of extremely low impedance to earth over these air gaps, and for extinguishing any flow of dynamic or follow current that may follow a lightning discharge to ground, no means other than the arc-extinguishing properties of the air gaps are necessary. This assures a positive cut-off of this current flow at the zero point of the generator voltage wave after the discharge has passed to ground.

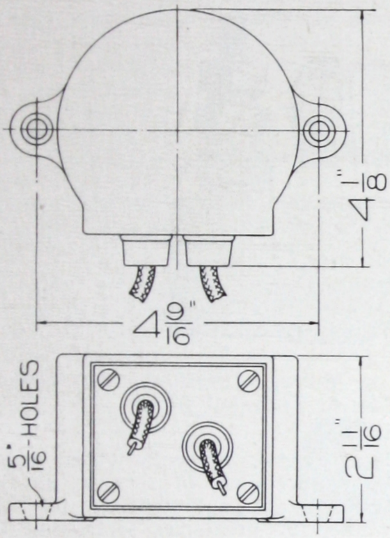
Type S arresters are regularly supplied with line and ground leads of No. 12 B&S gauge stranded cable, line leads being 36 inches long and ground lead 18 inches long and with hot galvanized strap iron hangers. These hangers are of 12 gauge metal and are provided with $\frac{5}{16}''$ holes on 2″ centers for accommodating ¼″ bolts or lags. All exposed bolts and nuts on the arrester are of hot galvanized iron. All galvanizing will meet the National Electric Light Association specifications.

Diagrams showing all essential dimensions of the Type S arrester are given on following page.

List No.		Std. Pkg.	List Price Each
50960	Type S Secondary Lightning Arrester, 0-350 volts	12	$4.00

KEYSTONE LIGHTNING ARRESTERS

Dimensional Diagrams



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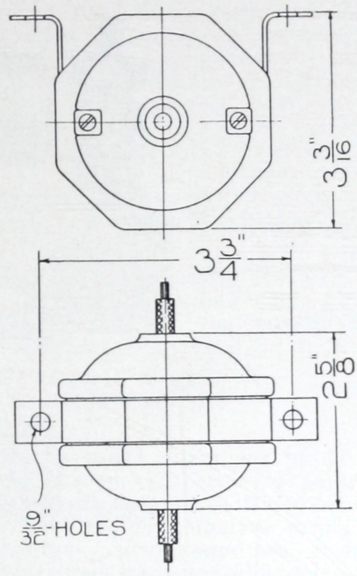
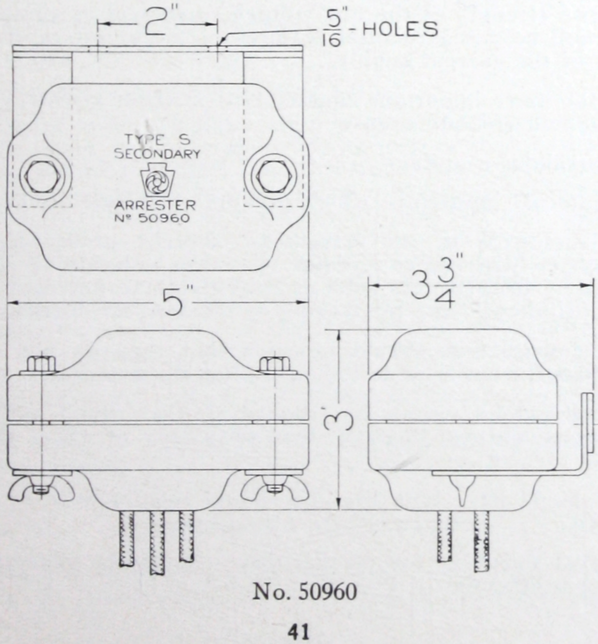


Nos. 50642, 50643



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KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Type

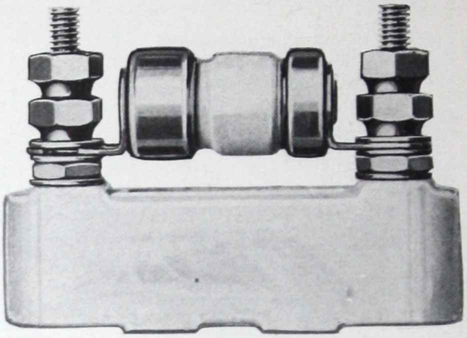


Fig. 1. Crystal Valve Low Voltage Lightning Arrester Mounted on A. R. A. Terminal Block

There are many types of low voltage electric systems where adequate lightning protection is necessary for the maintenance of service; as typical may be mentioned signal circuits of all types, telephone and telegraph circuits, fire alarm systems, remote metering circuits, the primaries of current transformers, and many other applications of a similar nature. The problem of protecting apparatus on such systems is generally similar to the problem of protecting apparatus on higher voltage circuits, with the difference, of course, that the arresters employed must be designed having in mind the relatively weaker dielectric strength of the low voltage equipment as compared with the high, and as well certain structural features of the arresters, dictated by the lower voltage of the current supply.

Some of the more important characteristics which arresters for low voltage systems should embody are—

a. Low breakdown voltage.

b. Low internal impedance which permits of a high discharge rate.

c. They should be of the valve type, thereby preventing the flow of dynamic or system current to ground following a lightning discharge, and preventing system disturbances such as heavy voltage fluctuations, or system grounds or short-circuits due to freezing of the arrester spark gaps.

d. Their construction should be such that they do not deteriorate in service nor change from their initial operating characteristics.

e. They should be strong and rugged so that rough handling or hard service conditions will not damage them physically or affect their operating characteristics.

f. They should have long life and should require little or no inspection or maintenance.

g. This cost should be low so that their use may be general on all equipment requiring protection.

KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Type

One of the most outstanding developments in lightning protective equipment in recent years is the Crystal Valve Lightning Arrester and during the past five years many thousands of these have been used in all voltage ranges up to and including 25,000 volts for the protection of equipment installed on power and lighting circuits; the Crystal Valve Arrester in this short time has been adopted as standard equipment by a large majority of the representative Central Stations of the country. It is now offered generally in several types for low voltage service and there is therefore now available to users of such equipment the outstanding advantages of the Crystal Valve Arrester which have in the past been available only to operators of systems of higher voltage ratings.

Briefly, the Crystal Valve Arrester embodies the successful application to lightning protective apparatus of the rectifying properties and valve characteristics of certain refractory conductive crystals. From the standpoint of lightning protection, the three most important factors involved in the design of lightning arresters are—

Fig. 2. Crystal Valve Low Voltage Lightning Arrester Cartridge

a. The arc-over or relief voltage.

b. The critical valve voltage.

c. The impedance of the discharge path.

Much detailed technical information relative to these factors, their theory and practical control, has been given in the section of this catalog devoted to high voltage types of Crystal Valve Arresters (pages 3-22, inc.), and is thus available to those interested in these phases of arrester design and operation. In general, the relief voltage of the Crystal Valve Arrester may be accurately controlled by the series air gap or gaps present in all types. The critical valve voltage may be controlled through suitably choosing the size of the crystals employed and the length of the crystal path. The impedance of the discharge path may be controlled by suitably varying the relation between the length of the crystal path, its sectional area and the physical dimensions of the crystals themselves. By properly co-ordinating and balancing these factors it is possible to secure an arrester which possesses any desired value of relief voltage, any desired critical valve voltage and an internal impedance of minimum value. It is the discovery and the practical application of these principles to the Crystal Valve Arrester that makes this arrester stand apart as such an outstanding and successful development in the lightning arrester field.

Construction and Operation

The primary element of all low voltage Crystal Valve Arresters is illustrated in Fig. 2. These elements or cartridges are made up with different

KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Type

electrical characteristics, of different physical dimensions and are incorporated in various assemblies to meet prescribed operating conditions; however, since the general construction and operation of the assemblies are identical a description of an elemental cartridge will cover the entire line.

Referring to Fig. 3. "A" shows the main body or tube of the cartridge which is made of Isolantite, one of the very best and strongest electrical insulators known; a brass disc "B" fits closely into one end of this tube, being so positioned that its outside face is in alignment with the corresponding end of the body tube. Isolantite disc "C" spaces brass electrode "D" from disc

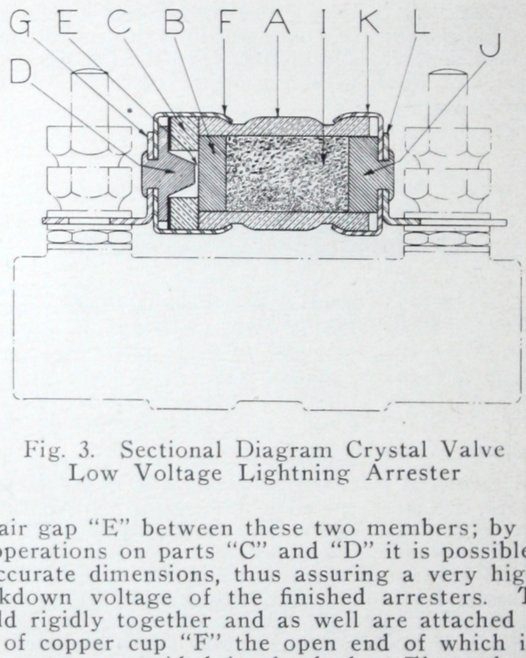


Fig. 3. Sectional Diagram Crystal Valve
Low Voltage Lightning Arrester

"B" to give the air gap "E" between these two members; by suitable grinding and machining operations on parts "C" and "D" it is possible to hold this air gap to highly accurate dimensions, thus assuring a very high degree of uniformity in breakdown voltage of the finished arresters. These spark gap elements are held rigidly together and as well are attached to the Isolantite body by means of copper cup "F" the open end of which is spun over and into a recess or groove provided in the body. Electrode "D" is provided with a protruding boss which extends through holes in cup "F" and terminal "G"; this boss being spun over rigidly attaches the terminal to the discharge electrode; to make an absolutely tight joint at this point—both from the electrical and mechanical standpoint as well as preventing even moisture from entering the interior of the arrester due to capillary leakage—these parts are sweated together.

In assembly, after the discharge gap end of the cartridge has been closed, the body is partially filled with "Crystallite" "I" of the desired size which is tightly compacted by subjecting the cartridge to continued mechanical vibration on special machines devised for the purpose. Brass contact disc "J" is next forced into contact with the "Crystallite" and is held in this position by

KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Type

copper cup "K," the open end of which is spun over and into the recess or groove in the body as seen. The contact disc "J," cup "K" and terminal "L" are rigidly held together by the spunover boss on disc "J" as well as by being sweated together. The type cartridge shown is adapted for mounting on a standard A. R. A. terminal block and Fig. 1 shows a cartridge of this type so mounted.

The operation of the arrester is very simple. Assuming that the spark gap end of the cartridge is connected to the line and the opposite end to the ground (the arrester will operate just as effectively if these connections are reversed), lightning discharges simply arc over the air gap and flow to ground across the gap and through the Crystallite, which, as before stated, offers a path of extremely low impedance to their passage. Since the arrester is of the valve type, and since the valve cut-off voltage is set somewhat in excess of the maximum voltage rating of the arrester practically no line or dynamic current follows the lightning discharge to ground, hence in operation the arrester acts simply as a safety valve for excess voltages built up on the line.

Summarized Advantages of Crystal Valve Lightning Arresters

Since these low voltage Crystal Valve Lightning Arresters operate on principles identical with those of the higher voltage types, the inherent advantages of the two types are identical. These have already been given for the higher voltage units on pages 21 and 22, to which reference should be made for this information.

Voltage Ratings

The voltage ratings given Crystal Valve Arresters effectively cover the usual standard ranges met in railway signal and other low voltage services. Efficient valve type arresters are sensitive to continuously applied circuit voltage above their maximum rating and while we have provided a very liberal factor of safety in the value of the critical voltage above the maximum voltage rating of the arrester, yet for efficient and satisfactory performance under average conditions it is necessary that when installed the maximum circuit voltage shall not exceed the maximum voltage rating of the arrester. The design of the Crystal Valve Arrester is so flexible that it is an easy matter to provide types to meet special circuit conditions. We shall be glad to make recommendations covering arresters for any such special conditions upon request.

Standard voltage ratings covering listed arresters will be found on following pages.

Installation

Crystal Valve Arresters should be generally employed in protecting all classes of apparatus subject to excess voltage whether from lightning or other causes. Where arresters are installed for line-to-ground protection, they should be installed as close as possible to the apparatus which is being protected. The same applies in cases where they are used as lightning shunts across coils—they should be attached as near to the coil terminals as possible.

KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Type

In line-to-ground protection use arresters rated for full line voltage. As a general rule arresters used as coil shunts should likewise be rated for full line voltage. It is generally feasible where numbers of arresters are installed at a given location to tie the ground terminals to a common ground bus and this practice is to be recommended.

Since the most generally used type of Crystal Valve Arrester, the Type LA, is designed for mounting on a standard A. R. A. terminal, it may be used to replace other less efficient arresters designed for similar mounting by simply substituting the Crystal Valve cartridge for the older type. This Company is glad to recommend lightning protection for special or involved circuits and invites requests for any such recommendations.

Grounding

Grounding Crystal Valve Arresters is no different from grounding other arresters. All grounds should be good and should be maintained in good condition if full efficiency is to be expected from the lightning arrester installation. *Bear in mind that lightning arresters can't have too good a ground.*

Among the general rules for grounding Crystal Valve Arresters may be mentioned the following:—

1. Provide short, straight wires from line to arrester and from arrester to ground. Wire of No. 6 B. & S. gauge or larger is recommended for this purpose.

2. Where a turn is necessary, avoid sharp angles by carrying the wire in a curve of long radius.

3. The standard indoor type arrester should preferably be installed with the long cupped end connected to line. In certain types both cups are of equal length; with such arresters it is immaterial which end is connected to line or ground. Arresters in porcelain cases and having line and ground leads attached should always be installed with the capped end of the porcelain up and the corresponding upper lead or leads connected to line.

4. All joints and connections should be carefully soldered and taped.

5. Run all arrester ground terminals to a common ground wire.

6. Where soldered joints are underground they should be heavily coated with asphaltum compound.

7. For further and more complete information on lightning arrester grounds, see our 48 page bulletin, "Lightning Arrester Grounds"; copies will be sent on request.

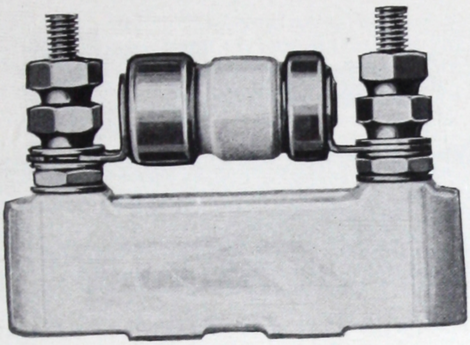
See page 59 of this bulletin for listing of ground fittings.

Inspection

Nothing but the most casual inspection of a Crystal Valve Lightning Arrester is necessary as owing to their construction and principles of operation trouble caused by them is very rare. In case one is suspected of being defective it may be tested between terminals with a megger or other suitable resistance measuring device.

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve—Type LA



Type LA Lightning Arrester
Mounted on A. R. A. Terminal Block

This arrester consists of a Crystal Valve cartridge designed for mounting on an A. R. A. Terminal Block. It is supplied either in the cartridge form only, less A. R. A. terminal block, or complete with terminal block and wood screws. Unless otherwise specified the cartridge only will be supplied.

Application—Designed for indoor or housed service where it will not be directly exposed to the elements; it is of the single pole type and may be used either for line-to-ground protection or as a coil or apparatus shunt on any circuit whose maximum voltage is within its rating.

Voltage Rating—Up to 50 volts D. C. or up to 220 volts A. C., maximum circuit voltage; circuit power capacity may be unlimited.

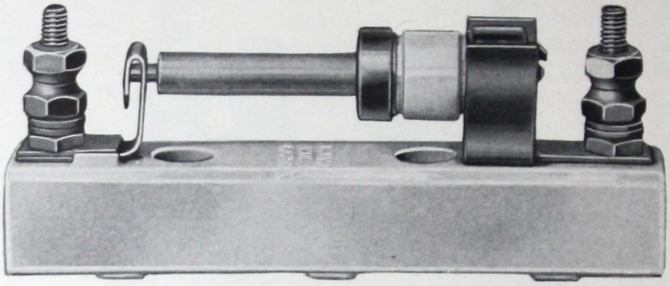
Packing—The No. 51056 Arrester is packed in cartons containing 12 cartridges; two of these cartons constitute a "Standard Package" as listed below. The No. 50949 Arrester is packed in cartons containing 6; four of these cartons constitute a "Standard Package" as listed below.

Dimensions—Drawing giving principal overall dimensions will be found on page 51.

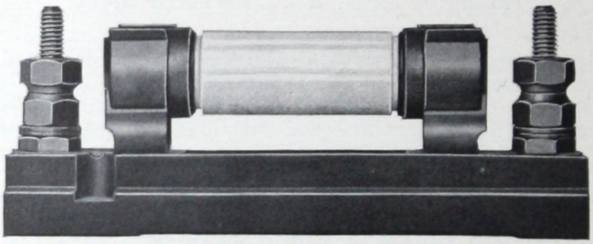
List No.		Std. Pkg.	List Price Each
51056	Type LA Crystal Valve Lightning Arrester, cartridge only	24	$2.65
50949	Type LA Crystal Valve Lightning Arrester, cartridge mounted on A. R. A. terminal block, including wood screws	24	3.00

KEYSTONE LIGHTNING ARRESTERS

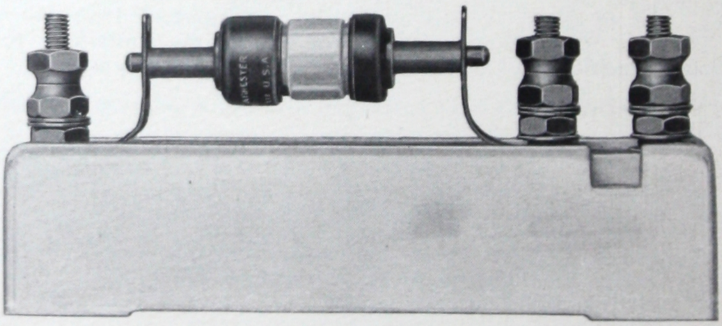
Low Voltage Signal Types LD, LE and LF



Application of Type LD Crystal Valve Lightning Arrester Cartridge



Application of Type LE Crystal Valve Lightning Arrester Cartridge



Application of Type LF Crystal Valve Lightning Arrester Cartridge

KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Types LD, LE and LF

The low voltage Crystal Valve lightning arresters are supplied not only in the LA type previously described for direct mounting on the standard A. R. A. terminal block, but in several modified designs adapting them to be used for replacing other types of low voltage arresters now in service, those types employing terminal blocks of special design. In this way users may obtain the highly efficient protection afforded by the Crystal Valve by merely slipping the proper Crystal Valve cartridge into the mounting of the older and less efficient unit. Several of these designs are illustrated on the preceding page; many other simple mounting arrangements can be provided adapting these arresters to other special terminal blocks, detailed information on which will be supplied upon request.

Application—The type LD cartridge adapts the Crystal Valve arrester to the standard General Electric vacuum tube base.

The type LE cartridge adapts the Crystal Valve arrester to the bases used with several of the Brach low voltage arresters; amongst these may be mentioned the Nos. 111, 26, 27, 27A, 60, 35, 36, 40A and 40B.

The type LF cartridge adapts the Crystal Valve arrester to the base used with the Brach type 29M heavy duty lightning arrester.

In several of these Brach arresters an overflow or auxiliary air gap is provided in shunt with the main vacuum or gas cartridge used. When replacing these with type LE or LF Crystal Valve cartridges this auxiliary gap should be removed, as it serves no useful purpose in connection with the operation of the Crystal Valve arrester and its removal eliminates the possibility of its becoming shorted with dust or dirt and so causing a leak or ground on the circuit.

Voltage Rating—The voltage rating of all these Crystal Valve cartridges is up to 50 volts D. C. or up to 220 volts A. C. maximum circuit voltage; they may be used either for line-to-ground protection or as a coil or apparatus shunt on any circuit where the maximum voltage is within this rating.

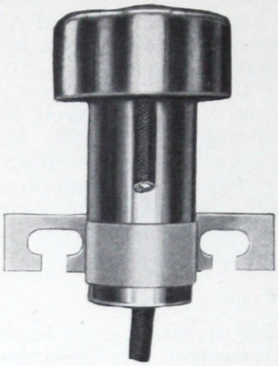
Packing—These arresters are packed in cartons containing 12 cartridges; two of these cartons constitute a "Standard Package" as listed below.

Dimensions—Drawings giving principal overall dimensions on these arresters will be found on page 52.

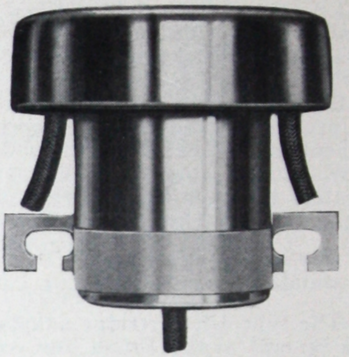
List No.		Std. Pkg.	List Price Each
51389	Type LD Crystal Valve lightning arrester cartridge only	24	$2.85
51390	Type LE Crystal Valve lightning arrester cartridge only	24	2.85
51391	Type LF Crystal Valve lightning arrester cartridge only	24	2.85

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve—Types LB and LC



Type LB Single Pole
Lightning Arrester



Type LC Double Pole
Lightning Arrester

Voltage Rating—Up to 750 volts A. C.

Application—These arresters have been designed for outdoor service especially for use on A. C. circuits operating generally at voltages of 440 and 550, such as are used in train control, for trickle chargers, in industrial plants, railroad yards and other places where power is transmitted and utilized at these voltages.

Construction—They consist essentially of a cartridge somewhat similar to that of the Type LA arrester already fully described on sheet 32 I (though of different electrical characteristics to adapt it to the higher voltage) enclosed in a glazed porcelain body and provided with line and ground leads. The Type LB arrester is of the single pole type, while the Type LC is of the double pole type. Line and ground leads are of No. 6 B. & S. gauge stranded cable, line leads being 36 inches long, while ground leads have a length of 18 inches. Mounting brackets are of hot galvanized strap iron drilled for accommodating ⅜-inch bolts or lags.

Dimensions—Drawings giving principal overall dimensions will be found on following page.

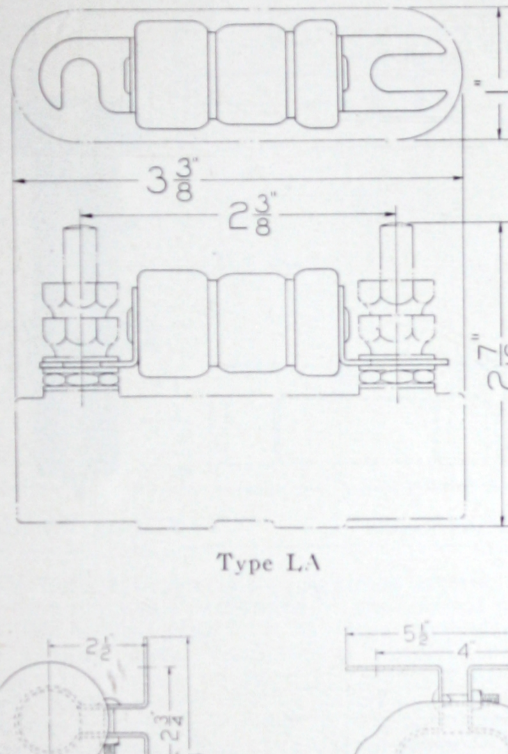
Packing—Types LB and LC arresters are packed in individual cardboard cartons, 24 of the Type LB or 12 of the Type LC arresters constituting a "Standard Package."

List No.		Std. Pkg.	List Price Each
51082	Type LB Crystal Valve Lightning Arrester, single pole type. Line lead 36 inches; ground lead 18 inches	24	$3.80
51081	Type LC Crystal Valve Lightning Arrester, double pole type. Line leads 36 inches; ground lead 18 inches	12	6.15

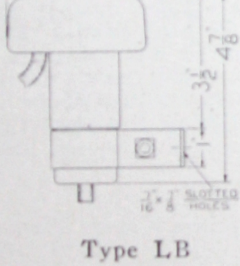
KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Type

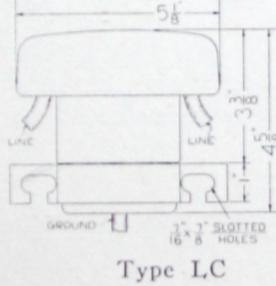
Dimensional Diagrams



Type LA



Type LB

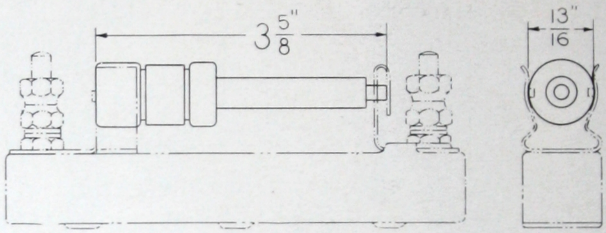


Type LC

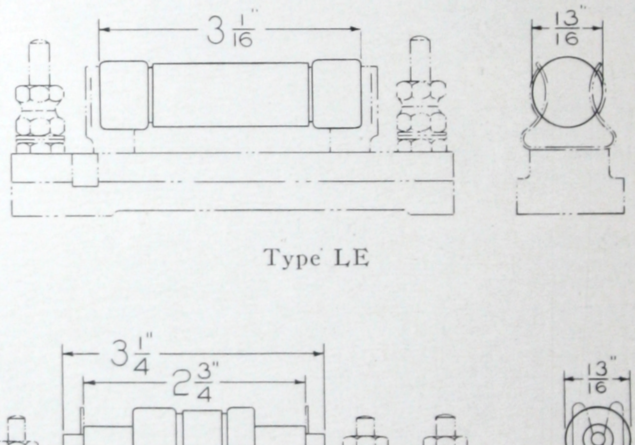
KEYSTONE LIGHTNING ARRESTERS

Low Voltage Signal Type

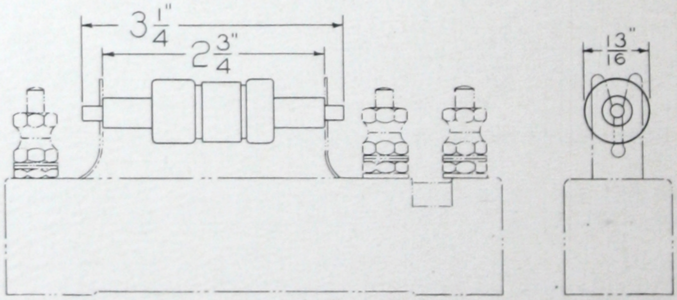
Dimensional Diagrams



Type LD



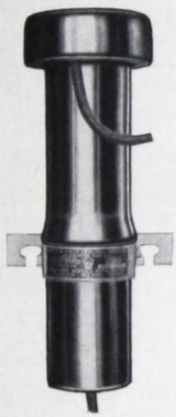
Type LE



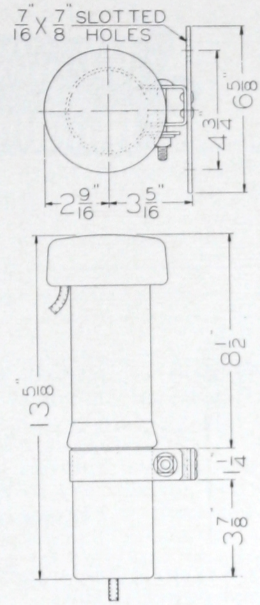
Type LF

KEYSTONE LIGHTNING ARRESTERS

Crystal Valve Type—4000-5000 Volts A. C.



Type CV Form 4



Dimension Diagram

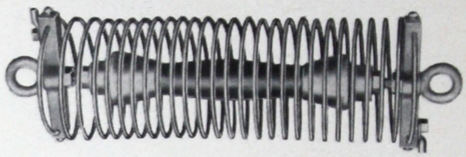
The type CV form 4 Crystal Valve lightning arrester illustrated above is suitable for use on any class of grounded or ungrounded circuit with voltages of from 4000 to 5000 *between phases.* It has been particularly designed for use on ungrounded railway signal transmission circuits operating at approximately 4400 volts. It operates on principles identical with those inherent to all other Crystal Valve arresters and by designing it particularly for a very limited voltage range it has been possible to incorporate to the greatest extent those qualities of high speed, efficiency, freedom from deterioration and other factors which are so predominant in the Crystal Valve arrester.

Body and cap of the CV form 4 arrester are made of the highest grade wet process porcelain; leads are of No. 6 B&S gauge cable, line lead being 24 inches long, ground lead 40 inches long. Unless otherwise specified on order, these arresters will be supplied as standard with type CA mounting bracket as shown above; if desired equipped with either CD, CE or CB mounting brackets, which are illustrated on page 28, this must be clearly specified on order. Arresters are supplied with any of these four mounting brackets at the standard list price below.

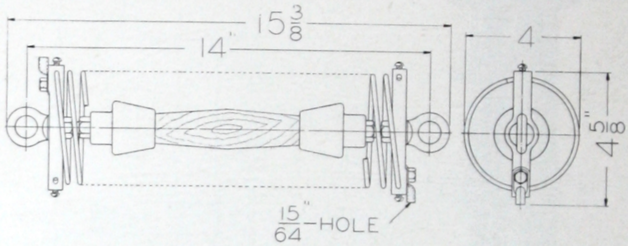
List No.		Std. Pkg.	List Price Each
51120	Type CV form 4 arrester	6	$19.25

KEYSTONE CHOKE COILS

Line Suspension, Type NWA



No. 51090



Dimension Diagram

Type NWA Keystone line suspension choke coils are designed particularly for railroad signal power circuits.

Where a railroad transmits power along the right of way many small transformers are generally employed to step down from the usual transmission voltage of 3300, 4400 or 6600 to 115 volts or lower for the operation of station illumination, signal equipment and similar light loads. Such small transformers are particularly susceptible to lightning troubles and many of the important railroads in addition to protecting them with lightning arresters, install a type NWA choke coil in each primary lead-in wire. The slight expense of so doing is more than justified in the freedom from power failures which follows, plus, of course, the savings which result from fewer transformer burnouts.

The type NWA choke coil is built around a 10,000 pound wood strain insulator, made from selected northern grown hickory, thoroughly treated by a special oil impregnating process which permanently excludes moisture and greatly lengthens the life of the wood; this is fitted with sherardized malleable iron terminals and drop forged sherardized steel eyes for suspension in the line conductors. The coil proper consists of 24 turns of No. 6 A. W. G. copper-clad wire, 30% conductiyity, 4 inches outside diameter clamped and permanently soldered to two brass end supports, which supports are securely attached to the strain terminal. Separable terminal lugs are provided for connection to the lead-in conductors.

The type NWA suspension choke coil is strongly made throughout, may be installed in any position and will be particularly effective in protecting small transformers in any of the services before mentioned.

Diagram showing principal dimensions is shown above.

List No.		List Price Each
51090	Type NWA Line Suspension Choke Coil	$6.00

GARTON-DANIELS LIGHTNING ARRESTERS

Direct Current Types

Garton-Daniels Lightning Arresters have long been and still are recognized as the standard arresters for the protection of electric railway and other D. C. equipment, and during the more than thirty-five years that they have been on the market hundreds of thousands of them have been functioning successfully in such service.

The present designs of Garton-Daniels direct current arresters follow the same fundamental principles of the earlier types, though constructional details have necessarily been changed with the progress of the art. Essentially they consist of the combination of—

a. A small air gap.

b. A low non-inductive series resistance.

c. A solenoidal type circuit breaker.

By referring to any of the following illustrations their operation will be clearly apparent. Lightning discharges enter the arrester through the line lead which is connected to upper binding post containing one electrode of the spark gap; jumping the spark gap they flow direct to ground through the non-inductive resistance, flexible pig tail and movable iron armature. The solenoidal winding is shunted across a portion of the resistor and the dynamic or power current following the discharge to ground is therefore partly shunted through this winding; this creates a magnetic field inside the solenoid, picking up the armature and consequently cutting off this flow of current to ground; the armature returns by gravity to its normal position. The operation is extremely simple and absolutely positive.

In all Garton-Daniels D. C. arresters the air gap is set to break down at voltages only slightly higher than normal—in the 750 volt arrester this air gap is only 1/40 inch; the resistor is non-inductive and has a low ohmic value —in this same arrester it averages but 50 ohms; it is made principally of carborundum in our own factory, and by our exclusive process which has been used continually for more than twenty-five years; these two factors are responsible for the exceptionally high efficiency possessed by all Garton-Daniels Arresters. It is of interest to state that the composition and manufacture of the resistor are such that its resistance remains constant indefinitely and is not affected by the passage of heavy surge currents or by ageing.

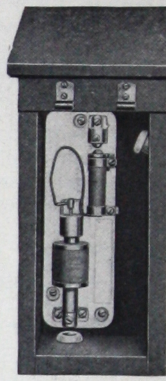
The circuit breaker is of the solenoid type, simple and positive in action. In cutting off the flow of dynamic current following the lightning discharge to ground all wear and tear incident thereto occurs at the circuit breaker contacts; the power arc is not blown out or otherwise extinguished at the air gap—it simply dies out at that point. There is consequently no burning of the gap electrodes, the gap does not lengthen and the initially high efficiency of the arrester is maintained practically indefinitely.

Detailed information on the several types of Garton-Daniels Lightning Arresters available for different voltages are given on the following pages.

GARTON-DANIELS LIGHTNING ARRESTERS

Type DF—Up to 350 Volts D. C.

No. 50016, Cover Removed



No. 50015, Cover Removed

Type DF Garton-Daniels lightning arresters are employed for protecting equipment on D. C. circuits of 350 volts or less. They find their widest application around industrial plants, in connection with mine haulage systems and in many other locations where this voltage is commonly used. Since the air gap distance between line and ground potential is but 1/50 inch, highly efficient protection is afforded.

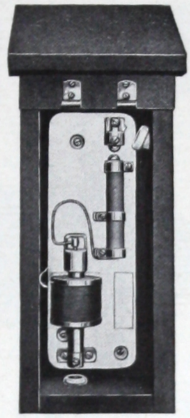
They are supplied in station type (without cover) and as well in both wood and iron covers. Both the wood and iron covers are of our standard design, are thoroughly weatherproof and the arrester elements carefully insulated therefrom. Both covers are supplied with insulating bushings for the lead-in wires.

List No.	Description	Dimensions	Net Weight Each	Std. Pkg.	List Price Each
50014	Station	9⅜ x 3 x 2¾ in.	3½ lbs.	12	$8.50
50016	Iron covered	14⅛ x 6½ x 4½ in.	13¼ lbs.	12	11.00
50015	Wood covered	16⅞ x 6¾ x 6¼ in.	9 lbs.	12	9.50

GARTON-DANIELS LIGHTNING ARRESTERS

Type EG—350 to 750 Volts D. C.

No. 50040, Cover Removed



No. 50041, Door Removed

Type EG Garton-Daniels Lightning Arresters are the arresters so generally and widely used for protecting equipment on D. C. railway circuits operating at voltages of from 350 to 750. They are also adapted for use on non-grounded power circuits operating in this voltage range.

Their efficiency is extremely high since the discharge path contains an air gap of only 1/40 inch and a non-inductive resistor of but 50 ohms. The circuit-breaker assures a positive cut-off of the flow of dynamic current following the lightning discharge to ground.

They are supplied in station type (without cover) and as well in both wood and iron covers, for both outdoor and car or locomotive installation. All covers are thoroughly weatherproof and are supplied with insulating bushings for the lead-in wires.

Type EG Arresters for Grounded Circuits

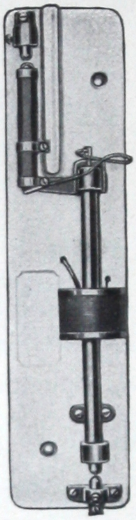
List No.	Description	Dimensions	Weight	Std. Pkg.	List Price Each
50039	Station	10¾ x 3⅝ x 3⅛ in.	5 lbs.	12	$9.00
50041	Wood covered pole	16⅞ x 6¾ x 6¼ in.	10 lbs.	12	10.50
50040	Iron covered pole	14⅛ x 6½ x 4½ in.	14½ lbs.	12	12.00
11780	Wood covered car	13 x 8½ x 6 in.	10 lbs.	12	10.50
11779	Iron covered car	14⅛ x 6½ x 4½ in.	14 lbs.	12	12.00

Type EG Arresters for Metallic Circuits

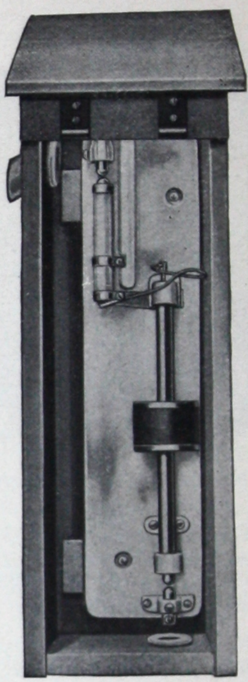
List No.	Description	Dimensions	Weight	Std. Pkg.	List Price Each
50193	Station	10¾ x 3⅝ x 3⅛ in.	5 lbs.	12	$9.00
50194	Wood covered pole	16⅞ x 6¾ x 6¼ in.	10 lbs.	12	10.50
50195	Iron covered pole	14⅛ x 6½ x 4½ in.	14½ lbs.	12	12.00
50030	Wood covered car	13 x 8½ x 6 in.	10 lbs.	12	10.50
50031	Iron covered car	14⅛ x 6½ x 4½ in.	14 lbs.	12	12.00

GARTON-DANIELS LIGHTNING ARRESTERS

Types EH, EJ and EK—750 to 2400 Volts D. C.



No. 50404



No. 50406, Door Removed

These arresters are for use in D. C. electric railway service operating at voltages of from 750 to 2400, and combine the same principles of design and operation which have proven so successful in all types of Garton-Daniels arresters.

Type EH arresters are rated for 750-1350-volt service.

Type EJ arresters are rated for 1350-1800-volt service.

Type EK arresters are rated for 1800-2400-volt service.

Air gap distance between line and ground potential in these arresters is respectively $\frac{1}{16}$, $\frac{3}{32}$ and $\frac{3}{16}$ inch; series resistance respectively averages 140, 225 and 350 ohms.

All arresters are heavily built to suit them to the severe conditions encountered in this service and are supplied in types as listed below.

List No.	Type	Description	Dimensions	Net Weight Each	Std. Pkg.	List Price Each
50338	EH	Station	19⅜ x 4 x 3⅞	11½ lbs.	12	$18.00
50339	EH	Wood car	21½ x 10½ x 6¾	21 lbs.	12	20.00
50400	EH	Wood covered	25¼ x 8⅜ x 7¾	21½ lbs.	12	20.00
50404	EJ	Station	19⅜ x 4 x 3⅞	11½ lbs.	12	20.00
50405	EJ	Wood car	21½ x 10½ x 6¾	21 lbs.	12	22.00
50406	EJ	Wood covered	25¼ x 8⅜ x 7¾	21½ lbs.	12	22.00
50426	EK	Station	49 x 8 x 17½	45 lbs.	6	40.00
50427	EK	Wood covered	49 x 13 x 15½	58 lbs.	6	44.00

LIGHTNING ARRESTER GROUND FITTINGS

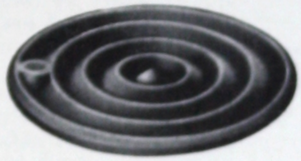
Garton-Daniels Types

External Point

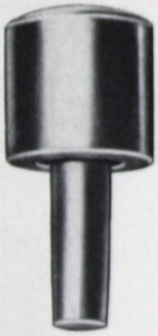
Internal Point

Brass Coupling

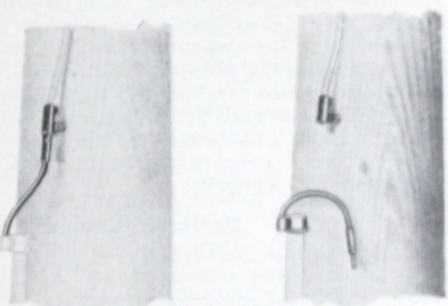
Brass Cap



Ground Plate



Driving Cap



Ground Wire Disconnector Showing Connected and Disconnected Positions

Garton-Daniels pipe ground fittings, used in connection with standard $\frac{3}{4}$- or 1-inch galvanized iron pipe, offer a convenient, efficient and economical method of making ground connections for lightning arresters and other purposes.

The points are made of malleable iron, heavily galvanized; the external type is internally threaded to screw onto the pipe while the internal type is designed to fit into the pipe, in either case providing the pipe with a strong sharp point permitting easy driving even under very adverse soil conditions. All ground pipes should be driven into the earth for a distance of from 6 to 10 feet or to a depth where they will be in continuously damp earth.

The caps listed are of brass, internally threaded to screw onto the upper end of the ground pipe and are provided with an integral lug into which the ground wire may be soldered; they provide efficient and relatively inexpensive means for attaching the ground wire to the pipe.

The brass coupling is employed largely in electric railway service where it is desired to tie the lightning arrester ground into the rail, and is provided with an integral lug into which such a connecting wire may be soldered. The lower end of the coupling threads onto the ground pipe while a shorter section of pipe provided with a brass cap screws into the upper end, the arrester ground wire being soldered into this cap.

LIGHTNING ARRESTER GROUND FITTINGS

Garton-Daniels Types

Driving caps are designed to slip over the upper end of a ground pipe to protect same and prevent splitting during the process of driving; they are made of steel and of such weight that they may be employed for driving a very large number of pipes without destruction.

Ground plates afford a very convenient method of obtaining a highly efficient ground; the type on preceding page is made of cast iron, heavily corrugated, and offers an exposed surface of 450 square inches. They are 12 inches in diameter, approximately ¾ inch thick and weigh 9 pounds each; they are supplied only in this size and are tapped for standard ¾ inch pipe. These ground plates are used largely in place of sheet copper ground plates on account of their greater efficiency, durability and economy.

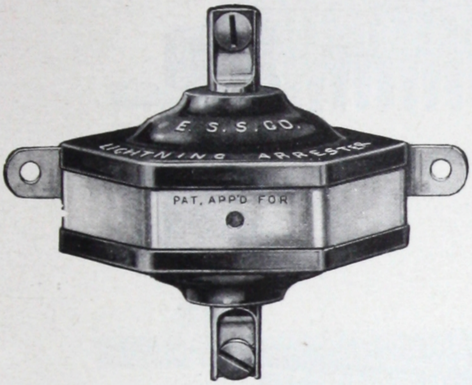
Ground wire disconnectors installed in the ground wire of lightning arresters permit the lineman to disconnect the ground as he climbs the poles and so provide an element of safety not readily obtainable otherwise. They consist of a cast brass receptacle designed to attach to the pole and a brass plug for engaging the receptacle; the receptacle is provided with a terminal into which a No. 4 or 6 B. & S. solid wire running from the lightning arrester ground terminal may be soldered; the plug is provided with 12 inches of No. 6 flexible copper cable for attachment to the ground.

For further and more complete information on the subject of grounding reference should be made to a new 48 page hand-book which we have recently issued entitled "Lightning Arrester Grounds." This is perhaps the most complete, practical booklet published on this subject and will be of great interest and assistance to every one interested in this phase of lightning protection; copies will be sent upon request.

		Std. Pkg.	List Price Each
	Malleable Ground Points		
50081	For ¾-inch pipe, external type	48	$ .45
50431	For ¾-inch pipe, internal type	48	.40
50437	For 1-inch pipe, external type	48	.55
50438	For 1-inch pipe, internal type	48	.50
	Brass Caps		
50079	For ¾-inch pipe, drilled for Nos. 4 or 6 wire	48	.45
50428	For ¾-inch pipe, drilled for No. 0 wire or cable	48	.45
50429	For ¾-inch pipe, drilled for ¼-inch cable	48	.45
50432	For 1-inch pipe, drilled for No. 4 or 6 wire	48	.55
50433	For 1-inch pipe, drilled for No. 0 wire or cable	48	.55
50434	For 1-inch pipe, drilled for ¼-inch cable	48	.55
	Brass Couplings		
50080	For ¾-inch pipe, drilled for Nos. 4 or 6 wire	.....	.40
50430	For ¾-inch pipe, drilled for No. 0 wire or cable	.....	.40
50435	For 1-inch pipe, drilled for Nos. 4 or 6 wire	.....	.50
50436	For 1-inch pipe, drilled for No. 0 wire or cable	.....	.50
	Driving Caps		
50936	Steel driving cap for ¾-inch pipe	.....	1.20
50937	Steel driving cap for 1-inch pipe	.....	1.40
	Miscellaneous		
50444	Ground wire disconnector for No. 4 or 6 B. & S. solid wire	.....	1.25
50440	Galvanized pipe coupling for ¾-inch pipe	.....	.15
50441	Galvanized pipe coupling for 1-inch pipe	.....	.20
50082	Iron ground plate, tapped for ¾-inch pipe	.....	1.20

RADIO LIGHTNING ARRESTERS

Keystone and Protex Types



"Keystone"

"Protex"

Keystone and Protex lightning arresters are designed especially for the protection of radio receiving apparatus from atmospheric lightning disturbances; in addition to this they practically eliminate any fire hazard which might exist due to an unprotected antenna.

They are both of the air gap type, and consist of a body of genuine Bakelite, heavy brass binding posts being moulded integrally in the body; the discharge electrodes are inside the body, where they are in an absolutely water, damp and dustproof enclosure and so located that any change in their relative positions (which would affect the gap) is practically impossible, hence assuring the continued maintenance of their initial highly efficient operating characteristics.

Binding posts are of approved design and will accommodate up to a No. 12 B&S stranded wire. Both arresters are attached to suitable supports by screws, these screws being provided with each arrester.

The Keystone arrester is supplied in individual cartons 3¼x3¼x3 inches single arrester complete weighing about 7 ounces; standard package consists of 48 arresters in these individual cartons, weighing about 27½ pounds.

The Protex arrester is likewise supplied in idividual cartons 2½x1⅝x1 inch, single arrester complete weighing about 2½ ounces; standard package consists of 48 arresters in these individual cartons, weighing about 8¾ pounds.

Diagrams covering installation and more detailed information on either type will be supplied on request.

List No.		List Price Each
50921	Keystone radio lightning arrester	$1.50
50929	Protex radio lightning arrester	.75

KEYSTONE RADIO GROUND FITTINGS

Pipe Types

Pipe Point

Pipe Cap

No. 50700

Keystone pipe ground fittings used with standard ¾-inch or 1-inch iron pipe offer a convenient, efficient and economical method of making ground connections for lightning arresters used for the protection of wireless aerials.

Points are made of malleable iron, heavily galvanized and threaded to fit standard ¾-inch or 1-inch pipe.

Brass caps are screwed to the top of the pipe and are drilled to receive No. 4 or 6 wire. A set screw is also provided.

Ground pipes should be driven in the earth for a distance of 6 to 10 feet, or to a point where they will be continually in damp earth.

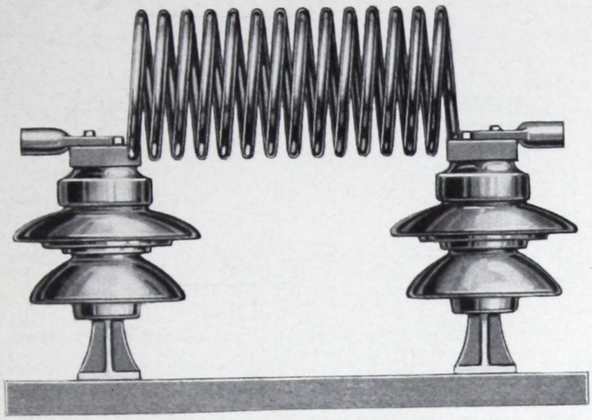
Keystone ground fittings are supplied in sets consisting of one point and one cap packed in a carton, the ¾-inch size outfit weighing approximately 1 pound and the 1-inch size 1⅜ pounds.

Standard package consists of 48 sets of fittings of one size, packed in a wooden box having a total weight of approximately 60 pounds and 85 pounds for the ¾-inch and 1-inch sizes respectively.

List No.		List Price Per Set
50700	Keystone radio ground fittings for ¾-inch pipe	$ .90
50920	Keystone radio ground fittings for 1-inch pipe	1.10

KEYSTONE CHOKE COILS

General Description



Typical Type L Choke Coil

The use of choke coils in connection with lightning arresters for protecting electrical equipment is so general and their theory and method of operation so well understood that no broad explanation need be given here. Briefly, the requirements of a satisfactory choke coil should embody high impedance characteristics for high frequency or steep wave front disturbances, good insulation, high mechanical strength and since many are installed in exposed locations they should be so constructed that little deterioration occurs in service.

Keystone choke coils meet these various requirements in a highly satisfactory manner, and are made in several types and for the various voltages and currents as listed on the following pages. Their general construction consists of a channel iron base to which are bolted the insulator assemblies, which assemblies in turn support the terminal blocks, terminals and coil proper.

Insulator pins are made of malleable iron and these with the cap are attached to the insulators proper by cement. All iron or steel parts going into the assembly are heavily hot galvanized, the galvanizing meeting the National Electric Light Association specifications. Franklin insulators are used throughout, these being made with special tops and holes to accommodate the fittings used. The shells of two and three-piece insulators are made and cemented together according to the standard Franklin design, with its many recognized advantages in respect to mechanical, electrical and thermal strength. The electrical characteristics of all Keystone choke coils are such that they will meet A. I. E. E. and other recognized standard tests.

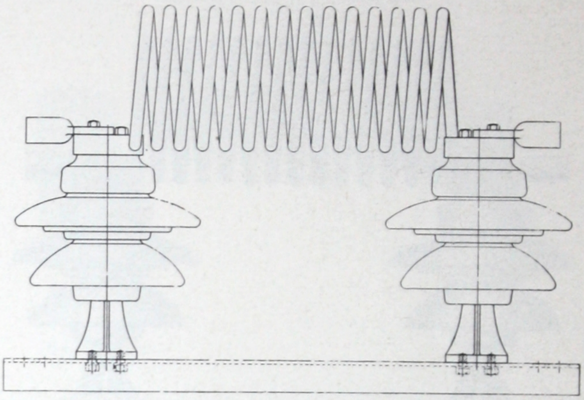
Coils proper are made of high conductivity copper and wound to several diameters, depending on the rating of the completed assembly; smaller coils are self-supported from the terminal blocks, while the larger ones are reinforced by impregnated maple bracing clamps. Separable terminals are provided for all capacities.

Wherever possible parts that may be interchangeably used are employed throughout the entire line; this not only reduces the cost of manufacture, which is reflected in lower costs to the user, but makes it possible for the user to readily replace any parts that may become defective in service—as, for instance, a broken insulator.

The construction of the entire line of Keystone choke coils is such as to provide ruggedness, strength and great durability at a reasonable cost. Wide factors of safety are employed throughout, thus rendering breakdowns, mechanical failures, etc., most improbable.

KEYSTONE CHOKE COILS

Type L, High Voltage



Typical Type L Choke Coil

Type L choke coils, as illustrated above, are designed for horizontal mounting in either indoor or outdoor locations, and are regularly supplied in voltage ratings and for the capacities as listed below. Their general construction consists of a channel iron base to which are bolted the insulator assemblies, which assemblies in turn support the coil proper.

All iron or steel parts are heavily hot galvanized. Coils proper are made of high conductivity copper; smaller coils are self-supported from the terminal blocks, while the larger ones are reinforced by impregnated maple bracing clamps. Separable terminals are provided for all capacities.

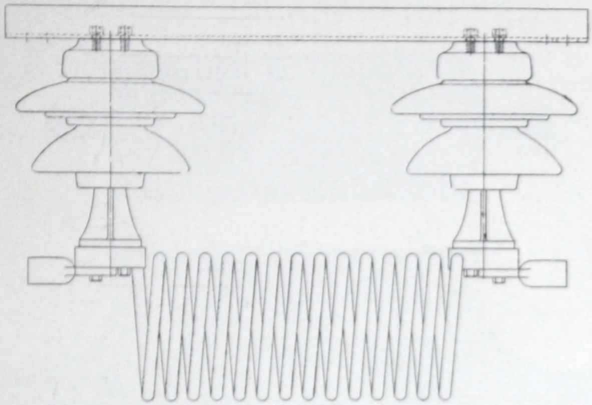
Since the details of coils necessarily vary, a full description of each individual coil is here impossible. Detailed blue prints will be supplied on request.

Choke coils listed have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51152	200 Amp.	4500	$21.00
51153	400 "	4500	25.00
51154	600 "	4500	31.00
51155	800 "	4500	36.00
51156	1200 "	4500	57.00
51157	200 "	7500	27.00
51158	400 "	7500	31.00
51159	600 "	7500	37.00
51160	800 "	7500	41.00
51161	1200 "	7500	63.00
51162	200 "	15000	35.00
51163	400 "	15000	39.00
51164	600 "	15000	44.00
51165	800 "	15000	70.00
51166	200 "	23000	41.00
51167	400 "	23000	46.00
51168	600 "	23000	55.00
51169	200 "	34500	45.00
51170	400 "	34500	50.00
51171	600 "	34500	60.00
51172	200 "	46000	50.00
51173	400 "	46000	65.00
51174	200 "	69000	70.00
51175	400 "	69000	90.00

KEYSTONE CHOKE COILS

Type LU, High Voltage



Typical Type LU Choke Coil

The type LU choke coils differ from the type L listed on preceding page in that they are of the inverted or underhung type, this construction frequently permitting of more convenient installation than would obtain with the type L; particularly is this true where coils are mounted directly on the pole top by lagging or bolting to the under side of two cross arms.

Their construction is similar to that of the type L and all parts for a given size type LU coil are interchangeable with the corresponding size type L.

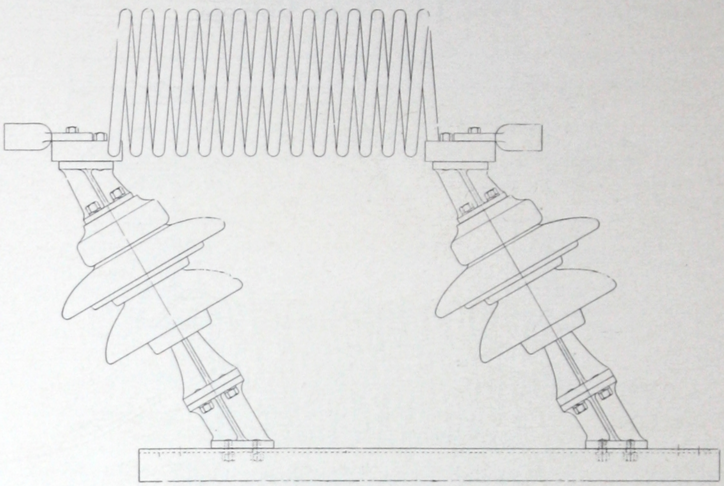
Since the details of coils necessarily vary, a full description of each individual coil is here impossible. Detailed blue prints will be supplied on request.

Choke coils listed have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51176	200 Amp.	4500	$21.00
51177	400 "	4500	25.00
51178	600 "	4500	31.00
51179	800 "	4500	36.00
51180	1200 "	4500	57.00
51181	200 "	7500	27.00
51182	400 "	7500	31.00
51183	600 "	7500	37.00
51184	800 "	7500	41.00
51185	1200 "	7500	63.00
51186	200 "	15000	35.00
51187	400 "	15000	39.00
51188	600 "	15000	44.00
51189	800 "	15000	70.00
51190	200 "	23000	41.00
51191	400 "	23000	46.00
51192	600 "	23000	55.00
51193	200 "	34500	45.00
51194	400 "	34500	50.00
51195	600 "	34500	60.00
51196	200 "	46000	50.00
51197	400 "	46000	65.00
51198	200 "	69000	70.00
51199	400 "	69000	90.00

KEYSTONE CHOKE COILS

Type LV, High Voltage



Typical Type LV Choke Coil

While the coil and terminal construction of the type LV choke coils are identical with similarly rated coils of the types L and LU, the mounting is of the angle type where insulators and supports are set at a 60-degree angle.

Through the use of strictly interchangeable parts a type L coil may be converted to a type LV through the simple insertion of angle filler blocks.

Type LV coils are designed for vertical installation on poles, steel frame work or walls and in various types of indoor and outdoor construction.

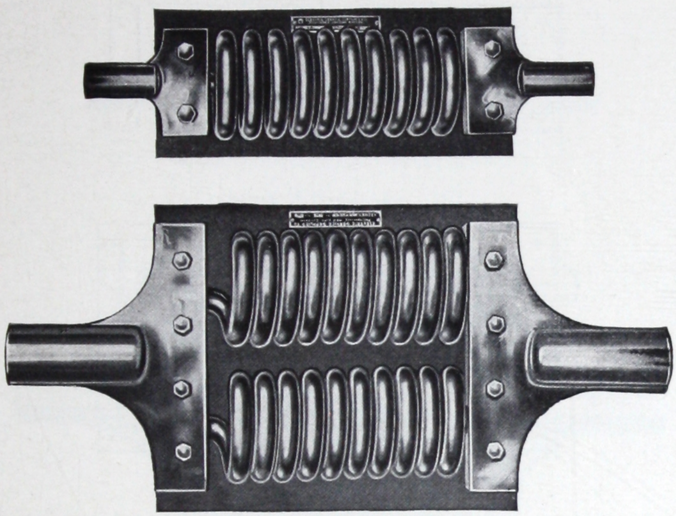
Detailed blue prints of any coil will be supplied on request.

Choke coils listed have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51200	200 Amp.	4500	$23.00
51201	400 "	4500	27.00
51202	600 "	4500	33.00
51203	800 "	4500	38.00
51204	1200 "	4500	59.00
51205	200 "	7500	29.00
51206	400 "	7500	33.00
51207	600 "	7500	39.00
51208	800 "	7500	43.00
51209	1200 "	7500	65.00
51210	200 "	15000	37.00
51211	400 "	15000	41.00
51212	600 "	15000	46.00
51213	800 "	15000	72.00
51214	200 "	23000	43.50
51215	400 "	23000	48.50
51216	600 "	23000	57.50
51217	200 "	34500	48.00
51218	400 "	34500	53.00
51219	600 "	34500	63.00
51220	200 "	46000	53.00
51221	400 "	46000	68.00
51222	200 "	69000	74.00
51223	400 "	69000	94.00

KEYSTONE CHOKE COILS

Type LM, up to 4500 Volts



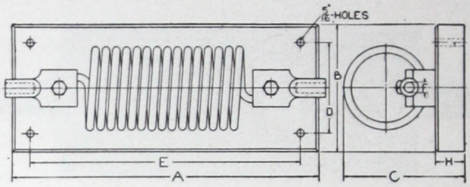
Type LM Choke Coils

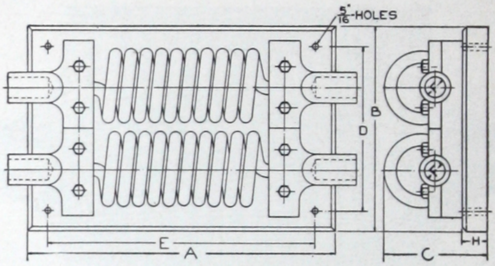
Type LM choke coils are of the helical type, mounted on blue Vermont marble bases, and are suited for indoor service on circuits up to 4500 volts. All coils are furnished with separable terminals, data on which is given on following page. In many instances coils of a given capacity are supplied with optional terminal constructions as shown in table, these having been found necessary in cases to meet special operating conditions. In ordering coils equipped with special terminals it is necessary to specify the list number of the standard coil and the list number of the special terminal; list price is the same for both standard and special constructions.

List No.	Capacity		Net Weight Each	List Price Each
50716	50 Amp.	Type LM choke coil	9½ lbs.	$16.50
50717	100 "	" LM " "	9½ "	17.00
50718	150 "	" LM " "	12 "	18.50
50719	200 "	" LM " "	12½ "	19.50
50720	250 "	" LM " "	13½ "	20.50
50721	300 "	" LM " "	16 "	22.50
50722	400 "	" LM " "	20 "	25.50
50723	500 "	" LM " "	24 "	30.00
50724	600 "	" LM " "	39 "	40.00
50725	800 "	" LM " "	44 "	50.00
50726	1000 "	" LM " "	55 "	57.50
50727	1200 "	" LM " "	70 "	68.50
50728	1600 "	" LM " "	95 "	88.50
50729	2000 "	" LM " "	105 "	116.00

KEYSTONE CHOKE COILS

Type LM, up to 4500 Volts





Dimension Diagrams

Dimensional Data—Standard Construction

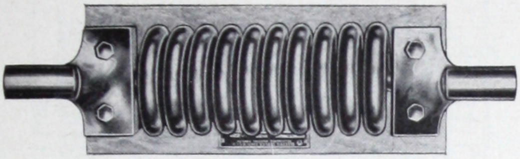
List No.	A	B	C	D	E	F	H	Terminal Lugs Per End	Max. Size Conductor Accommodated: Solid Wire	Max. Size Conductor Accommodated: Cable
50716	10½″	4⅜″	4⅝″	2⅞″	9 ″	9/32″	1½″	1	No. 2 B&S	No. 3 B&S
50717	10½″	4⅜″	4⅝″	2⅞″	9 ″	11/32″	1½″	1	1/0 "	1 "
50718*	13 ″	5 ″	4¾″	3¼″	11¼″	13/32″	1½″	1	2/0 "	1/0 "
50719	13 ″	5 ″	4⅞″	3¼″	11¼″	7/16″	1½″	1	3/0 "	2/0 "
50720*	13 ″	5 ″	5 ″	3¼″	11¼″	½″	1½″	1	4/0 "	3/0 "
50721	13 ″	5 ″	5 1/16″	3½″	11½″	11/16″	1½″	1		300.000 c.m.
50722*	14 ″	5 ″	5¼″	3½″	12½″	¾″	1½″	1		400.000 "
50723	14 ″	5 ″	5 5/16″	3½″	12½″	1 ″	1½″	1		650.000 "
50724*	15 ″	10 ″	5 1/16″	8¼″	13¼″	1 1/32″	1½″	1		750.000 "
50725*	15 ″	10 ″	5¼″	8¼″	13¼″	1 5/32″	1½″	1		900.000 "
50726*	15 ″	10 ″	5 5/16″	8¼″	13¼″	1⅜″	1½″	1		1.250.000 "
50727*	15 ″	13 ″	5¼″	10½″	12½″	1½″	1½″	1		1.500.000 "
50728*	18 ″	16 ″	5¼″	13 ″	15 ″	1 5/32″	1½″	2		900.000 "
50729*	18 ″	16 ″	5 5/16″	13 ″	15 ″	1⅜″	1½″	2		1.250.000 "

*Optional terminal constructions.

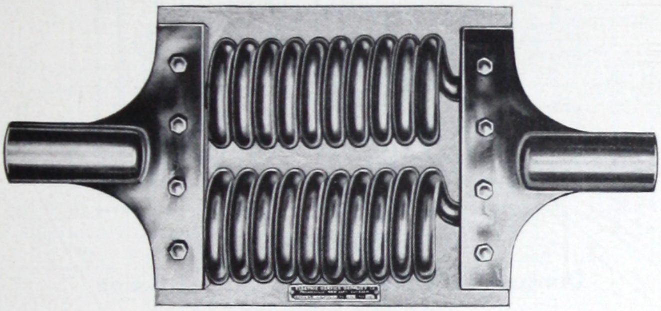
List No.	Terminal Lugs Per End	Terminal Lug List No.	Lug Drilling	Max. Size Conductor Accommodated: Solid Wire	Max. Size Conductor Accommodated: Cable
50718	1	51370	1 5/32 in.	No. 3 B&S	No. 2/0 B&S
50720	1	51371	11/16 "		300.000 c.m.
50722	1	51372	27/32 "		500.000 "
50724	2	51373	27/32 "		500.000 "
50725	2	51374	27/32 "		500.000 "
50726	2	51375	1 "		700.000 "
50727	3	51376	27/32 "		500.000 "
50728	3	51377	1 "		700.000 "
50729	3	51378	1 "		700.000 "

KEYSTONE CHOKE COILS

Types AF and AMF, up to 2500 Volts



Type AF Choke Coil



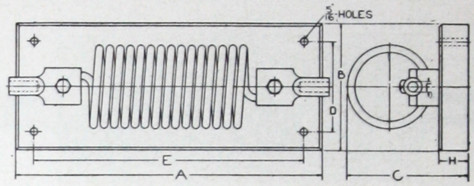
Type AMF Choke Coil

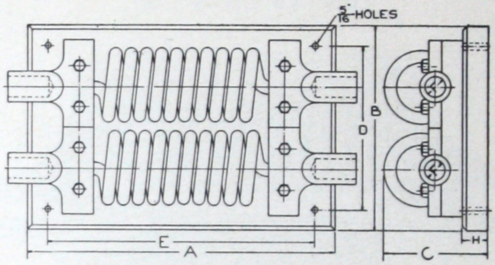
Types AF and AMF choke coils are of the helical eype, mounted on ebony asbestos bases, and are suited for indoor service in circuits up to 2500 volts. All coils are furnished with separable terminals, data on which is given on following page. In many instances coils of a given capacity are supplied with optional terminal constructions as shown in table, these having been found necessary in cases to meet special operating conditions. In ordering coils equipped with special terminals it is necessary to specify the list number of the standard coil and the list number of the special terminal; list price is the same for both standard and special constructions.

List No.	Capacity		Net Weight Each	List Price Each
50052	50 Amp.	Type AF choke coil	8½ lbs.	$11.00
50713	100 "	" AF " "	8½ "	11.50
50714	150 "	" AF " "	11 "	12.50
50055	200 "	" AF " "	11½ "	13.50
50056	250 "	" AF " "	12½ "	15.00
50715	300 "	" AF " "	15 "	17.00
50058	400 "	" AF " "	18 "	21.00
50059	500 "	" AF " "	21 "	25.00
50060	600 "	" AMF " "	34 "	34.00
50061	800 "	" AMF " "	38 "	43.50
50062	1000 "	" AMF " "	50 "	52.50
50063	1200 "	" AMF " "	65 "	61.50
50065	1600 "	" AMF " "	90 "	81.50
50066	2000 "	" AMF " "	100 "	102.00

KEYSTONE CHOKE COILS

Types AF and AMF, up to 2500 Volts





Dimension Diagrams

Dimensional Data—Standard Construction

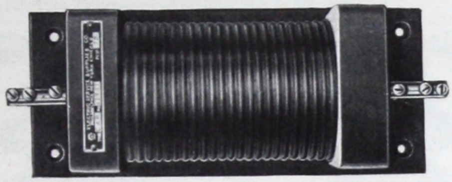
List No.	A	B	C	D	E	F	H	Terminal Lugs Per End	Max. Size Conductor Accommodated Solid Wire	Cable
50052	10½"	4⅜"	4⅛"	2⅞"	9 "	9/32"	1 "	1	No. 2 B&S	No. 3 B&S
50713	10½"	4⅜"	4⅛"	2⅞"	9 "	11/32"	1 "	1	1/0 "	1 "
50714*	13 "	5 "	4¼"	3¼"	11¼"	13/32"	1 "	1	2/0 "	1/0 "
50055	13 "	5 "	4⅜"	3¼"	11¼"	7/16"	1 "	1	3/0 "	2/0 "
50056*	13 "	5 "	4½"	3¼"	11¼"	½"	1 "	1	4/0 "	3/0 "
50715	13 "	5 "	4 9/16"	3½"	11½"	11/16"	1 "	1		300.000 c.m.
50058*	14 "	5 "	4¾"	3½"	12½"	¾"	1 "	1		400.000 "
50059	14 "	5 "	4 13/16"	3½"	12½"	1 "	1 "	1		650.000 "
50060*	15 "	10 "	4 13/16"	8¼"	13¼"	1 1/32"	1¼"	1		750.000 "
50061*	15 "	10 "	5 "	8¼"	13¼"	1 5/32"	1¼"	1		900.000 "
50062*	15 "	10 "	5 1/16"	8¼"	13¼"	1⅜"	1¼"	1		1.250.000 "
50063*	15 "	13 "	5 "	10½"	12½"	1½"	1¼"	1		1.500.000 "
50065*	18 "	16 "	5 "	13 "	15 "	1 5/32"	1¼"	2		900.000 "
50066*	18 "	16 "	5 1/16"	13 "	15 "	1⅜"	1¼"	2		1.250.000 "

*Optional terminal constructions.

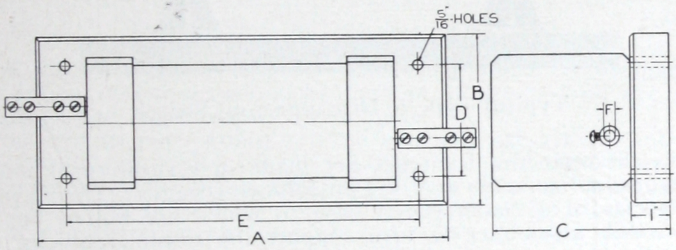
List No.	Terminal Lugs Per End	Terminal Lug List No.	Lug Drilling	Max. Size Conductor Accommodated Solid Wire	Cable
50714	1	51379	15/32 in.	No. 3/0 B&S	No. 2/0 B&S
50056	1	51380	11/16 "		300.000 c.m.
50058	1	51381	27/32 "		500.000 "
50060	2	51382	27/32 "		500.000 "
50061	2	51383	27/32 "		500.000 "
50062	2	51384	1 "		700.000 "
50063	2	51385	1 "		700.000 "
50063	3	51386	27/32 "		500.000 "
50065	3	51387	1 "		700.000 "
50066	3	51388	1 "		700.000 "

KEYSTONE CHOKE COILS

Type C, Car Service



Car Choke Coil



Dimension Diagram

Type C car choke coils are wound of solid copper wire on a wood mandrel, which in turn is mounted on an ebony asbestos base; coils proper are wound with air spacing between turns, which spacing is filled with insulating material after assembly, the whole then being taped and painted. They are fitted with standard cylindrical wire connectors for connecting into the car circuit, and are suitable for use on direct current circuits up to 1500 volts.

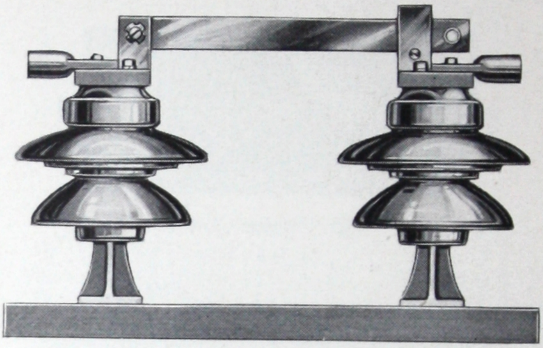
Listing, with dimensional and other data, is given below.

List No.	A	B	C	D	E	F	Max. Size Conductor Solid Wire	Accommodated Cable
50707	10½ in.	4⅜ in.	4 9/16 in.	2⅞ in.	9 in.	9/32 in.	No. 2 B. & S.	No. 3 B. & S.
50708	12 "	5 "	4 9/16 "	3½ "	10½ "	11/32 "	1/0 "	1 "
50709	12 "	5 "	4 9/16 "	3½ "	10½ "	⅜ "	2/0 "	1/0 "
50710	12 "	5 "	4 9/16 "	3½ "	10½ "	7/16 "	3/0 "	2/0 "
50711	13 "	5 "	4⅞ "	3½ "	11½ "	½ "	4/0 "	3/0 "
50712	13 "	5 "	4⅞ "	3½ "	11½ "	19/32 "		4/0 "

List No.	Capacity		Net Weight Each	List Price Each
50707	100 Amp.	Type C, car choke coil	10 lbs.	$8.50
50708	150 "	" " " "	11 "	9.00
50709	200 "	" " " "	12½ "	9.50
50710	250 "	" " " "	13½ "	10.00
50711	300 "	" " " "	14½ "	10.50
50712	400 "	" " " "	15½ "	11.50

KEYSTONE DISCONNECTING SWITCHES

General Description



Typical Type R Disconnecting Switch

Keystone disconnecting switches are made in several types and for the various voltages and currents as listed on following pages. Their general construction consists of a channel iron base to which are bolted the insulator assemblies, which assemblies in turn support the terminal blocks, terminals and switch proper.

Insulator pins are made of malleable iron and these with the caps are attached to the insulators proper by cement. All iron or steel parts going into the assembly are heavily hot galvanized, the galvanizing meeting the National Electric Light Association specifications. Franklin insulators are used throughout, these being made with special tops and holes to accommodate the fittings used. The shells of two and three-piece insulators are made and cemented together according to the standard Franklin design, with its many recognized advantages in respect to mechanical, electrical and thermal strength. The electrical characteristics of all Keystone switches are such that they will meet A. I. E. E. and other recognized standard tests.

The blades and wipes of these switches are made of machine-finished, pure, hard-drawn copper, the wipes being pinned and sweated into slots milled into heavy terminal blocks. Tension screws are provided for the wipes at each end and blades are ground to an accurate fit before being shipped. Wipes on all switches are flared to facilitate closing and separable terminals are provided for all capacities.

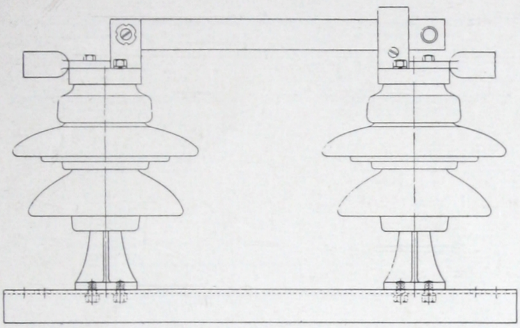
Wherever possible parts that may be interchangeably used are employed throughout the entire line; this not only reduces the cost of manufacture, which is reflected in lower costs to the user, but makes it possible for the user to readily replace any part that may become defective in service as, for instance, a broken insulator.

Disconnecting switches are not regularly fitted with switch locks, though these will be supplied so equipped when specified, at a cost slightly higher than for the standard switch. The lock used is the Keystone standard double wedge type.

The construction of the entire line of Keystone disconnecting switches is such as to provide ruggedness, strength and great durability at a reasonable cost. Wide factors of safety are employed throughout thus rendering breakdowns, punctures, mechanical failures, etc., most improbable.

KEYSTONE DISCONNECTING SWITCHES

Type R, High Voltage



Typical Type R Disconnecting Switch

Type R disconnecting switches, as illustrated above, are designed for horizontal mounting in either indoor or outdoor locations, and are supplied in voltage ratings and capacities as listed below.

All iron or steel parts going into the assembly are heavily hot galvanized. Tension screws are provided for the wipes at each end and blades are ground to an accurate fit before being shipped. Wipes on all switches are flared to facilitate closing and separable terminals are provided for all capacities.

Type R disconnecting switches are not regularly fitted with switch locks, though they will be supplied equipped with the Keystone double wedge type when specified at a small additional cost.

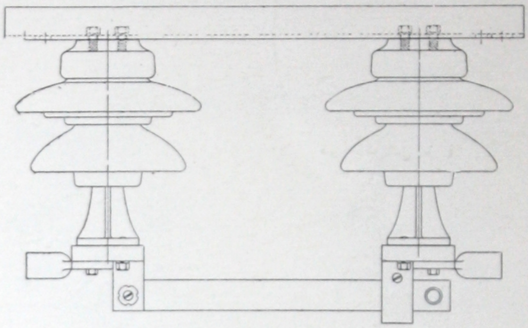
Detailed prints covering any of the switches listed below will be supplied upon request.

Switches listed have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51224	200 Amp.	4500	$16.00
51225	400 "	4500	20.50
51226	600 "	4500	28.00
51227	800 "	4500	34.00
51228	1200 "	4500	47.00
51229	200 "	7500	17.00
51230	400 "	7500	21.50
51231	600 "	7500	29.00
51232	800 "	7500	35.00
51233	1200 "	7500	48.00
51234	200 "	15000	19.00
51235	400 "	15000	24.00
51236	600 "	15000	33.00
51237	800 "	15000	40.00
51238	200 "	23000	26.50
51239	400 "	23000	31.50
51240	600 "	23000	41.50
51241	200 "	34500	36.00
51242	400 "	34500	42.00
51243	600 "	34500	52.00
51244	200 "	46000	47.00
51245	400 "	46000	53.50
51246	200 "	69000	62.00
51247	400 "	69000	70.00

KEYSTONE DISCONNECTING SWITCHES

Type RU, High Voltage



Typical Type RU Disconnecting Switch

The type RU disconnecting switches differ from the type R listed on preceding page in that they are of the inverted or underhung type, often permitting of more convenient installation than would obtain with the type R.

Their construction is similar to that of the type R and all parts for a given size type RU switch are interchangeable with similar parts of the corresponding size type R. This interchangeability of parts not only results in lower costs to the user, but makes it possible for the user to readily replace any part that may become defective in service or to change from one type of construction to another better suited to the conditions of a particular installation.

Type RU disconnecting switches are not regularly fitted with switch locks, though they will be supplied so equipped when specified at a small additional cost. The lock used is the Keystone standard double wedge type.

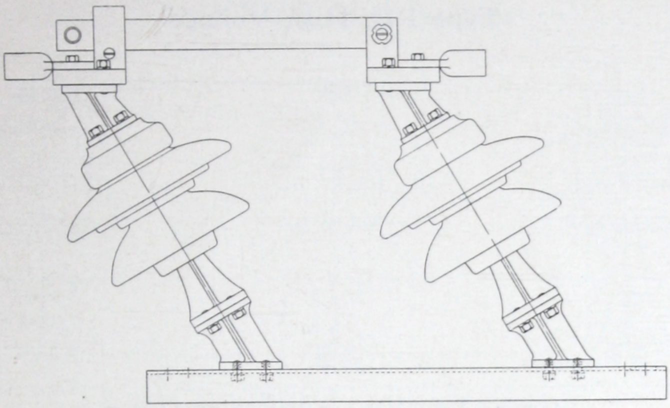
Detailed blue prints of any of the switches will be supplied upon request.

Switches listed have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51248	200 Amp.	4500	$16.00
51249	400 "	4500	20.50
51250	600 "	4500	28.00
51251	800 "	4500	34.00
51252	1200 "	4500	47.00
51253	200 "	7500	17.00
51254	400 "	7500	21.50
51255	600 "	7500	29.00
51256	800 "	7500	35.00
51257	1200 "	7500	48.00
51258	200 "	15000	19.00
51259	400 "	15000	24.00
51260	600 "	15000	33.00
51261	800 "	15000	40.00
51262	200 "	23000	26.50
51263	400 "	23000	31.50
51264	600 "	23000	41.50
51265	200 "	34500	36.00
51266	400 "	34500	42.00
51267	600 "	34500	52.00
51268	200 "	46000	47.00
51269	400 "	46000	53.50
51270	200 "	69000	62.00
51271	400 "	69000	70.00

KEYSTONE DISCONNECTING SWITCHES

Type RV, High Voltage



Typical Type RV Disconnecting Switch

While the blade and terminal construction of the type RV disconnecting switches are identical with similarly rated switches of the types R and RU, the mounting is of the angle type where insulators are set at a 60-degree angle. Through the use of strictly interchangeable parts a type R switch may be converted to a type RV through the simple insertion of angle filler blocks.

Type RV switches are designed for vertical installation on poles, steel frame work or other indoor and outdoor construction.

Type RV disconnecting switches are not regularly fitted with switch locks, though they will be supplied so equipped when specified at small additional cost. The lock used is the Keystone standard double wedge type.

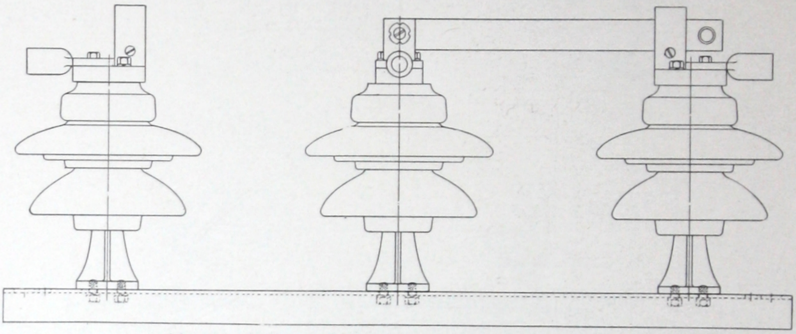
Detailed blue prints of any of the switches will be supplied upon request.

These switches have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51272	200 Amp.	4500	$18.00
51273	400 "	4500	22.50
51274	600 "	4500	30.00
51275	800 "	4500	36.00
51276	1200 "	4500	49.00
51277	200 "	7500	19.00
51278	400 "	7500	23.50
51279	600 "	7500	31.00
51280	800 "	7500	37.00
51281	1200 "	7500	50.00
51282	200 "	15000	21.00
51283	400 "	15000	26.00
51284	600 "	15000	35.00
51285	800 "	15000	42.00
51286	200 "	23000	29.00
51287	400 "	23000	34.00
51288	600 "	23000	44.00
51289	200 "	34500	39.00
51290	400 "	34500	45.00
51291	600 "	34500	55.00
51292	200 "	46000	50.00
51293	400 "	46000	56.50
51294	200 "	69000	66.00
51295	400 "	69000	74.00

KEYSTONE DISCONNECTING SWITCHES

Type RD, High Voltage



Typical Type RD Disconnecting Switch

Type RD disconnecting switches embody the same structural features as are found in the type R listed in preceding pages, but are of the double throw type. Separable terminals are provided, standard construction being as shown above with contact or end terminals aligned axially with the switch base, while the hinge or center terminal is at right angles to the switch base.

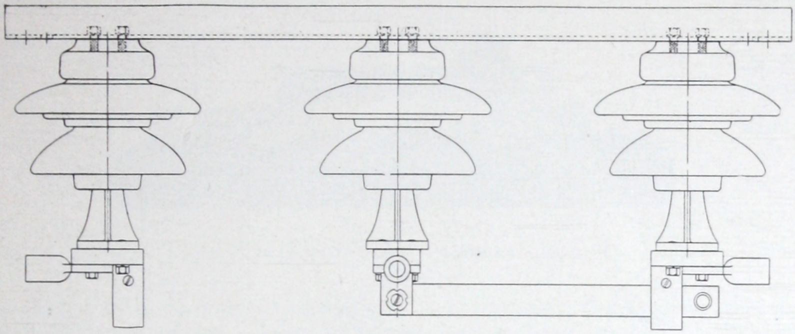
While the general construction of these switches has already been covered in the descriptive matter preceding these listings, the details of individual switches necessarily vary and a description of each individual switch is here impossible. Detailed blue prints of any switch will be supplied on request.

These switches have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51296	200 Amp.	4500	$24.00
51297	400 "	4500	30.75
51298	600 "	4500	42.00
51299	800 "	4500	51.00
51300	1200 "	4500	70.50
51301	200 "	7500	25.50
51302	400 "	7500	32.25
51303	600 "	7500	43.50
51304	800 "	7500	52.50
51305	1200 "	7500	72.00
51306	200 "	15000	28.50
51307	400 "	15000	36.00
51308	600 "	15000	49.50
51309	800 "	15000	60.00
51310	200 "	23000	39.75
51311	400 "	23000	47.25
51312	600 "	23000	62.25
51313	200 "	34500	54.00
51314	400 "	34500	63.00
51315	600 "	34500	78.00
51316	200 "	46000	70.50
51317	400 "	46000	80.25
51318	200 "	69000	93.00
51319	400 "	69000	102.50

KEYSTONE DISCONNECTING SWITCHES

Type RUD, High Voltage



Typical Type RUD Disconnecting Switch

Type RUD disconnecting switches are of the inverted or underhung type, embody the same principles and structural features as are found in the type RU listed in preceding pages, but are of the double throw type. Separable terminals are provided, standard construction being as shown above with contact or end terminals aligned axially with the switch base, while the hinge or center terminal is at right angles to the switch base.

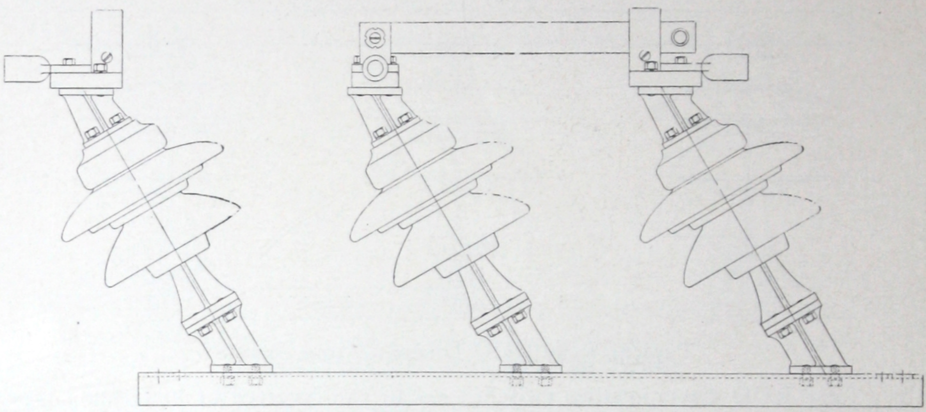
While the general construction of these switches has already been covered in the descriptive matter preceding these listings, the details of individual switches necessarily vary and a description of each inidvidual switch is here impossible. Detailed blue prints of any switch will, however, be gladly sent on request.

Switches listed have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51320	200 Amp.	4500	$24.00
51321	400 "	4500	30.75
31322	600 "	4500	42.00
51323	800 "	4500	51.00
51324	1200 "	4500	70.50
51325	200 "	7500	25.50
51326	400 "	7500	32.25
51327	600 "	7500	43.50
51328	800 "	7500	52.50
51329	1200 "	7500	72.00
51330	200 "	15000	28.50
51331	400 "	15000	36.00
51332	600 "	15000	49.50
51333	800 "	15000	60.00
51334	200 "	23000	39.75
51335	400 "	23000	47.25
51336	600 "	23000	62.25
51337	200 "	34500	54.00
51338	400 "	34500	63.00
51339	600 "	34500	78.00
51340	200 "	46000	70.50
51341	400 "	46000	80.25
51342	200 "	69000	93.00
51343	400 "	69000	102.50

KEYSTONE DISCONNECTING SWITCHES

Type RVD, High Voltage



Typical Type RVD Disconnecting Switch

While the blade and terminal construction of the type RVD disconnecting switches are identical with similarly rated switches of the types RD and RUD and they likewise are of the double throw type, the mounting of the type RVD is of the angle type, where insulators and supports are set at a 60-degree angle with the base. Like the type RV they are designed particularly for vertical installation on poles, steel frame work or walls and find application in various types of indoor and outdoor construction.

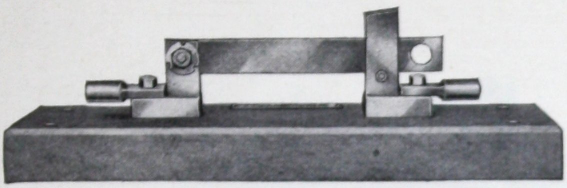
Detailed blue prints of any switch will be supplied on request.

Switches listed have a tolerance of 5% above rated voltage, except ratings 15,000 volts and below, which are maximum.

List No.	Capacity	Voltage	List Price Each
51344	200 Amp.	4500	$27.00
51345	400 "	4500	33.75
51346	600 "	4500	45.00
51347	800 "	4500	54.00
51348	1200 "	4500	73.50
51349	200 "	7500	28.50
51350	400 "	7500	35.25
51351	600 "	7500	46.50
51352	800 "	7500	55.50
51353	1200 "	7500	75.00
51354	200 "	15000	31.50
51355	400 "	15000	39.00
51356	600 "	15000	52.50
51357	800 "	15000	63.00
51358	200 "	23000	43.50
51359	400 "	23000	51.00
51360	600 "	23000	66.00
51361	200 "	34500	58.50
51362	400 "	34500	67.50
51363	600 "	34500	82.50
51364	200 "	46000	74.50
51365	400 "	46000	84.75
51366	200 "	69000	99.00
51367	400 "	69000	108.50

KEYSTONE DISCONNECTING SWITCHES

Type RM, High Voltage



Type RM Switch, 200 Ampere Capacity

The type RM disconnecting switch is essentially the switch structure of the type R mounted on a blue Vermont marble base instead of the channel base, pins, insulators and caps as is standard with the type R. The type RM switch may safely be used on circuits operating at voltages up to 2500, it being installed inside power or sub-station, or in some other location where it is not exposed to the elements.

Detailed blue prints of any of the switches listed will be furnished upon request.

List No.	Voltage	Capacity	List Price Each
50557	Up to 2,500	100 Amp.	$14.50
50558	Up to 2,500	200 "	15.00
50559	Up to 2,500	300 "	17.00
50560	Up to 2,500	400 "	19.50
50561	Up to 2,500	500 "	24.50
50562	Up to 2,500	600 "	28.50
50563	Up to 2,500	800 "	35.00
50564	Up to 2,500	1,000 "	42.00
50565	Up to 2,500	1,200 "	50.00

KEYSTONE SWITCH HOOKS

Nos. 50418-19-20 Switch Hooks

Owing to their construction and installation, disconnecting switches cannot be opened or closed by hand; for these purposes, switch hooks are provided. Keystone switch hooks consist of a well-seasoned wood pole fitted on the end with a metal ferrule and pin. This pin engages in the hole in the blade, and by this means the switches are opened and closed.

Switch hooks in three standard lengths are listed below.

List No.		List Price Each
50418	Switch hook, any voltage, 4 feet long	$3.00
50419	Switch hook, any voltage, 8 feet long	4.00
50420	Switch hook, any voltage, 12 feet long	5.00

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